TABLE OF CONTENTS ~ PRELIMINARY

3 Preliminary
3.1 General
3.1.1 Policy overview
3.1.2 Design information
3.1.3 Definitions
3.1.4 Abbreviations and notation
3.1.5 References
3.1.5.1 Direct
3.1.5.2 Indirect
3.2 Bridges
3.2.1 Identification numbers
3.2.2 Stream and river crossings
3.2.2.1 Hydrology
3.2.2.2 Hydraulics
3.2.2.3 Backwater
3.2.2.4 Freeboard
3.2.2.5 Road grade overflow
3.2.2.6 Streambank protection
3.2.2.7 Scour
3.2.2.7.1 Types
3.2.2.7.2 Design conditions
3.2.2.7.3 Evaluating existing structures
3.2.2.7.4 Depth estimates
3.2.2.7.5 Countermeasures
3.2.2.7.5.1 Riprap at abutments
3.2.2.7.5.2 Riprap at piers
3.2.2.7.5.3 Wing dikes
3.2.2.7.6 Coding
3.2.3 Highway crossings
3.2.3.1 Clearances
3.2.3.2 Ditch drainage
3.2.4 Railroad crossings
3.2.4.1 BNSF and UP overhead structures
3.2.4.1.1 Vertical clearance
3.2.4.1.2 Horizontal clearance
3.2.4.1.3 Piers
3.2.4.1.4 Bridge berms
3.2.4.1.5 Drainage
3.2.4.1.6 Barrier rails and fencing
3.2.4.2 Non-BNSF and -UP overhead structures
3.2.4.2.1 Vertical clearance
3.2.4.2.2 Horizontal clearance
3.2.4.2.3 Piers
3.2.4.2.4 Bridge berms
3.2.4.2.5 Drainage
3.2.4.2.6 Barrier rails and fencing
3.2.4.3 Underpass structures
3.2.4.4 Submittals
3.2.5 Pedestrian and shared use path crossings
3.2.6 Superstructures
3.2.6.1 Type and span
3.2.6.1.1 CCS J-series
3.2.6.1.2 Single-span PPCB HSI-series
3.2.6.1.3 Two-span BT-series

3.2.6.1.4 Three-span PPCB H-series
3.2.6.1.5 Three-span RSB-series
3.2.6.1.6 PPCB
3.2.6.1.7 CWPG
3.2.6.2 Width
3.2.6.2.1 Highway
3.2.6.2.2 Sidewalk, separated path, and bicycle lane
3.2.6.3 Horizontal curve
3.2.6.3.1 Spiral curve
3.2.6.4 Alignment and profile grade
3.2.6.5 Cross slope drainage
3.2.6.6 Deck drainage
3.2.6.7 Bridge inspection/maintenance accessibility
3.2.6.8 Barrier rails
3.2.7 Substructures
3.2.7.1 Skew
3.2.7.2 Abutments
3.2.7.3 Berms
3.2.7.3.1 Slope
3.2.7.3.2 Toe offset
3.2.7.3.3 Berm slope location table
3.2.7.3.4 Recoverable berm location table
3.2.7.3.5 Slope protection
3.2.7.4 Piers and pier footings
3.2.8 Cost estimates
3.2.9 Preliminary situation plans
3.2.10 Permits and approvals
3.2.10.1 Waterway
3.2.10.2 Railroad
3.2.10.3 Highway
3.2.11 Forms

3 Preliminary

3.1 General

The following series of articles provides a set of guidelines for development of type, size, and location (TS&L) plans. TS&L plans are of two types: (1) Preliminary Situation Plans for bridges, walls, and culverts that require final design and (2) Pipe Plat Plans for pipe culverts. Within the guidelines and throughout the development of TS&L plans it is important that the designer apply sound engineering judgment, including technical and economic analysis.

This series of articles replaces the applicable articles of the 2000 edition of *Guidelines for Preliminary Design of Bridges and Culverts*. These guidelines provide a partial update of the 2000 edition.

3.1.1 Policy overview

Within the Office of Bridges and Structures, the preliminary bridge design section develops the preliminary layouts for highway structures. For bridges, walls, culverts, and miscellaneous structures that require final design, the section assembles information and develops a preliminary situation plan sheet so that a designer in one of the final design sections can perform the structural design and develop final plans for a contract letting. For pipe culverts the section develops the layout in sufficient detail that the Office of Design can reference the information on their final road plans for a contract letting.

The development of all preliminary structure plans includes a number of tasks such as:

- Analyzing hydrology and hydraulics;
- Analyzing road geometrics;
- Determining the type, size, and location of structures;
- Developing a layout in the CADD system;
- Attending field reviews;
- Coordinating with other Iowa DOT offices, public entities, and outside agencies;
- Estimating cost alternatives;
- Obtaining flood plain permit approvals; and
- Coordinating with other regulatory agencies.

The tasks are outlined below, first for bridges and then for culverts.

{List of tasks will be added in the future.}

3.1.2 Design information

The designer will need to access information from several sources to perform preliminary design, including the following:

- Plans for existing structures, including as-built plans, from Electronic Records Management System (ERMS);
- Bridge maintenance reports from ERMS and SIIMS;
- A new site survey from Office of Design;
- Soil boring information from the Office of Design;
- Aerial photographs from the Office of Design and/or web sites;
- Aerial agricultural photographs (drainage maps) from the Photogrammetry/Preliminary Survey Section in the Office of Design;
- Topographic maps from the Office of Bridges and Structures, the Office of Design and/or web sites; and
- Field exams.

Plans for existing structures will give a good indication of the site when an existing structure was built, widened, and/or extended, and comparison with a new survey will indicate any site changes that have occurred since previous construction.

The designer should make appropriate use of CADD to integrate support programs such as Geopak and GeoMedia when developing type, size, and location (TS&L) plans.

3.1.3 Definitions

~~**AutoBridge** is software that links Excel, Word, and MicroStation to automate various aspects of bridge design and detailing for constant width and multiple span pretensioned prestressed concrete beam bridges.~~

Berm slope location table (BSLT) gives toe and top of berm information to aid the contractor in construction of the berm.

Bicycle lane or **bike lane** is a portion of a roadway which has been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists.

Detailed Flood Insurance Study (FIS) analysis of a community's flood prone areas which determines the 100 year flood elevation and floodway for certain streams.

Electronic Reference Library (ERL) contains plans, specifications, and manuals and is available on the Iowa Department of Transportation's web site.

Electronic Records Management System (ERMS) has been developed to enable electronic use and management of documents within the Iowa Department of Transportation. ERMS includes aerial photographs, existing bridge plans, bridge inspection records, and other documents useful for preliminary bridge design.

Floodway is the portion of the floodplain that must be left unobstructed for the conveyance of the 100 year flood.

Flood Risk Reduction Project (FRRP) is typically defined as a Corps of Engineers designed flood protection levee system.

Grading surface is defined by key points on the Berm Slope Location Table [BDM 3.2.7.3.3].

Green book is the office term for the Office of Design's manual of Road Design Details.

Ordinary high water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas [Code of the Federal Register 33 CFR Part 328.3].

Red book is the office term for the Office of Design's manual of Standard Road Plans.

Revetment is a relatively general term for a facing that supports an embankment. **Riprap** is a more specific term for the layer of various sized rocks or broken concrete used to protect a streambank from erosion. With respect to streambank protection the terms **revetment** and **riprap** usually are interchangeable. **Revetment Stone** is the quarry industry's product that may be used for streambank erosion protection.

Section Leader is the supervisor of the Office of Bridges and Structures preliminary bridge section, final design section, or consultant coordination section.

Shared use path is a bikeway physically separated from motorized vehicular traffic by an open space or a barrier and either within the highway right-of-way or within an independent right-of-way. Shared use paths may also be used by pedestrians, skaters, wheelchair users, joggers, and other non-motorized users. See AASHTO's 1999 *Guide for the Development of Bicycle Facilities* [BDM 3.1.5.2].

Typical is the office term for a Road Design Detail.

3.1.4 Abbreviations and notation

3R, Resurfacing, Restoration, Rehabilitation; a series of terms that refers to a Federal Highway Administration highway project funding program
ADT, average daily traffic
AREMA, American Railway Engineering and Maintenance-of-Way Association
B0, event code for Office of Bridges and Structures concept
B1, event code for Office of Bridges and Structures layout
B2, event code for structural/hydraulic design plans to Office of Design
BTB, BTC, BTD, BTE, standard cross sections for pretensioned prestressed concrete bulb tee beams
BNSF, Burlington Northern Santa-Fe Railway
BSLT, berm slope location table
CCS, continuous concrete slab
CFR, Code of Federal Regulations
CLOMR, Conditional Letter of Map Revision issued by FEMA
CMP, corrugated metal pipe
CWPG, continuous welded plate girder

D_{50}, median revetment stone diameter
D0, event code for predesign concept
D2, event code for design field exam
DA, drainage area
ERL, Electronic Reference Library
ERMS, Electronic Records Management System
FEMA, Federal Emergency Management Agency
FHWA, Federal Highway Administration
FIS, Flood Insurance Study
HDPE, high density polyethylene
HEC-2, U.S. Army Corps of Engineers **H**ydrologic **E**ngineering **C**enter hydraulic analysis software
HEC-RAS, U.S. Army Corps of Engineers **H**ydrologic **E**ngineering **C**enter – **R**iver **A**nalysis **S**ystem hydraulic analysis software
IAC, Iowa Administrative Code
IFI, intermediate foundation improvement
IHRB, Iowa Highway Research Board
Iowa DNR, Iowa Department of Natural Resources
Iowa DOT, Iowa Department of Transportation
LOMR, Letter of Map Revision issued by FEMA
LT, left
M, distance between chord and arc at midpoint of horizontally curved bridge [BDM 3.2.6.3]
MCS, main-channel slope, a variable in USGS WRIR 03-4120
MSE, mechanically stabilized earth, generally associated with retaining walls
N or N-value, standard penetration test number of blows per foot (300 mm). N also may be given as SPT NO, the Standard Penetration Test Number in the soils information chart.
n-coefficient, Manning's Coefficient [BDM 3.2.2.3]
NFIP, National Flood Insurance Program
NHS, National Highway System
NRCS, Natural Resources Conservation Service
PE, preliminary engineering
PEP, polyethylene pipe
POT, point on tangent
PPCB, pretensioned prestressed concrete beam
Q_2, Q_{50}, Q_{100}, Q_{500}, estimated channel discharge at 2-, 50-, 100-, or 500-year design flood frequency
RBLT, recoverable berm location table
RCB, reinforced concrete box, a type of culvert
RCP, reinforced concrete pipe
ROW, right of way
RSB, rolled steel beam
RSS, reinforced steepened slope
RT, right
SI&A, Structure Inventory and Appraisal
SIIMS, Structure Inventory and Inspection Management System
SUDAS, (Iowa) Statewide Urban Design and Specifications
TS&L, type, size, and location
UP or **UPRR,** Union Pacific Railroad
USGS, United States Geological Survey
WSPRO, water surface profile software developed by the U.S. Geological Survey

3.1.5 References

3.1.5.1 Direct

[IDOT PPM policy number] refers to a policy in the Iowa Department of Transportation *Policies and Procedures Manual.*

[IDOT SS article] refers to Iowa Department of Transportation *Standard Specifications for Highway and Bridge Construction, Series 2009* with article number. (Available on the Internet at: http://www.iowadot.gov/erl/index.html)

[OD DM article, table, or figure] refers to the Office of Design, Highway Division *Design Manual* with article, table, or figure number. (Available on the Internet at: http://www.iowadot.gov/design/dmanual/manual.html?reload)

[OD RDD sheet number] refers to the Office of Design, Highway Division "Road Design Details" with sheet number. Formerly the detail manual was referred to as the "green book." (Available on the Internet at: http://www.iowadot.gov/design/desdet.htm)

[OD SRP sheet number] refers to an Office of Design, Highway Division "Standard Road Plan" with sheet number. Formerly the plan manual was referred to as the "red book." (Available on the Internet at: http://www.iowadot.gov/design/stdrdpln.htm)

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3.2 Bridges

The information in Article 3.2 for preliminary design of bridges generally is organized by task in the design process. The sequence of the tasks for a specific design project will not necessarily follow the sequence in this article but, before completing a preliminary design, the designer should review the information on each of the following topics that are applicable.

- Identification numbers
- Stream and river crossings
- Highway Crossings
- Railroad crossings
- Pedestrian and Shared Use Path Crossings
- Superstructures
- Substructures
- Cost estimates
- Preliminary Situation plans
- Permits and approvals
- Forms

When developing the site for bridge projects the designer should endeavor to use standard bridges as much as possible. The office has four types of standard bridges described in the superstructures article:

- Three-span continuous concrete slab (CCS) bridges, J-series [BDM 3.2.6.1.1],
- Single-span pretensioned prestressed concrete beam (PPCB), HSI-series [BDM 3.2.6.1.2],
- Three-span pretensioned prestressed concrete beam (PPCB) bridges, H-series [BDM 3.2.6.1.4], and
- Three-span rolled steel beam (RSB) bridges [BDM 3.2.6.1.5].

Additionally the office has several series of standard pretensioned prestressed concrete beams [BDM 3.2.6.1.6] that may be used to assemble bridges with lengths and numbers of spans that vary from the standard bridges. For spans above 155 feet or for bridges on significant horizontal curves the designer may select a continuous welded plate girder superstructure [BDM 3.2.6.1.7].

~~Efficiency during the design process also is improved if a bridge project can make use of AutoBridge software, which is described in more detail in a following article [BDM 3.2.6].~~

3.2.1 Identification numbers

A new bridge will be assigned three identification numbers: a bridge design number, an FHWA number, and a bridge maintenance number. The preliminary designer need only assign the bridge design number; the FHWA and bridge maintenance numbers are assigned later by others. Assigning the bridge design number requires consideration of record keeping, letting dates, and final design plan preparation. The preliminary designer shall follow the rules in Table 3.2.1.

Table 3.2.1. Bridge design number assignment rules

Design Condition	**Similar Geometry** [(1)]	**Design numbers**
Single bridge with a common approach roadway crown that requires a split into two bridges with a 2-inch (50 mm) separation to reduce temperature forces [(2)]	---	One
Two new bridges (duals) with open median	Yes	One
Two new bridges with separate roadway approach crown, separated by a 2-inch (50 mm) gap	Yes	One
	No [(3)]	Two
Widening of existing duals	For widening, yes	One
	For widening, no	Two
Multi-staged construction involving left and right bridges, each letting	Yes	One
	No [(3)]	Two
Two new bridges in different lettings that otherwise could be considered duals	Yes	Two

Table notes:

(1) Similar geometry should be interpreted as similar length, width, and skew.

(2) An example for this design condition would be a bridge greater than 80 feet (24.400 m) wide for a local road with turn lanes and raised median.

(3) On a case-by-case basis, with approval of the supervising Section Leader, if left and right bridge geometry is very close to similar the designer may assign a single design number.

For corridor projects the preliminary designer shall assign a file number for each preliminary engineering (PE) number. For smaller projects without a PE number, assign a file number for each project. To minimize file numbers, miscellaneous structures generated before a project is complete shall be associated with the original file number.

3.2.2 Stream and river crossings

Stream and river crossings require the designer to consider the waterway in detail and, in some cases, obtain permits for the bridge. The topics listed below are to be considered in design of bridges over streams and rivers and are discussed in subarticles that follow.

- Hydrology
- Hydraulics
- Backwater
- Freeboard
- Roadgrade overflow
- Streambank Protection
- Scour

As a general rule, the design discharge for rural structures on Iowa's primary highway system is the 50-year flood. For bridge locations where the upstream flood damage potential is high or where the site is located in a detailed Flood Insurance Study (FIS) area, the 100-year flood should be the design discharge. When a project is located in a detailed FIS area, the published peak discharges and flood elevations are used for design. The average velocities (Q/A) through a bridge waterway opening typically should range between 6 and 8 feet/second (1.8 and 2.4 m/s) for the design discharge. The designer should calculate the following discharges for each bridge.

- Q_2 - for Corps of Engineers Section 404 permit information regarding quantity of fill (usually revetment) in cubic yards/running foot (cubic meters/running meter)
- Q_{50} - to determine velocity through bridge opening, backwater, and freeboard to the low superstructure elevation
- Q_{100} - to determine design scour and backwater and velocities through the bridge opening

- Q_{500} or $Q_{Overtopping}$ - to determine check (maximum) scour

3.2.2.1 Hydrology

Reliable estimates of flood-frequency discharges are essential for the economical planning and safe design of bridges and other structures located over streams. Hydrology for bridges should include the following peak discharges for design: Q_2, Q_{50}, Q_{100} and Q_{500} or $Q_{overtopping}$. In special cases the designer may need to determine additional discharges for the project.

The designer has several methods for determining estimated discharges, which are listed below.

- **Federal Emergency Management Agency (FEMA) Flood Insurance Studies (FIS)**

  Many cities and counties in Iowa have detailed FISs. Typically, a community with an FIS has adopted regulations that prohibit increasing the 100 year flood elevation or encroaching upon a regulated floodway. The discharges and flood elevations in an FIS are usually legally binding and are used by the Iowa Department of Natural Resources when issuing flood plain development permits. If different design discharges are proposed, prior approval from the DNR is required. When a project is located outside the detailed area of an FIS but could impact flood elevations or flood prone properties of an FIS community, the FIS information should be used for analysis.

  It should be noted that when a project involves development within a regulatory floodway (including bridge piers), the analysis must show that the project will not cause an increase in the 100 year flood elevation. If a "no rise" condition cannot be obtained when encroaching upon a regulatory floodway, the designer may need to apply to FEMA for revisions to the FIS by means of a Conditional Letter of Map Revision (CLOMR). After a CLOMR is issued and construction is completed a Letter of Map Revision (LOMR) is obtained by submitting as-built plans.

  Information from an FIS, if available, is preferred over other sources. The designer should check the FEMA website below to determine the current status of a community's FIS:

  http://msc.fema.gov/webapp/wcs/stores/servlet/StoreCatalogDisplay?storeId=10001&catalogId=10001&langId=-1&userType=G

  ~~The designer may obtain a current list of FISs from the Flood Plain Permits Section of the Iowa DNR. A current list is available as Appendix A to Instructional Memorandum to County Engineers 3.131 on the Iowa DOT web site at the following address.~~

  ~~http://www.iowadot.gov/local_systems/publications/county_im/3_131/im_3_131.pdf~~

  Projects located in communities that are mapped by the National Flood Insurance Program as flood prone but do not show the 100-year flood elevation are not subject to the same requirements as a project located in a detailed FIS area. If a community does not have an adopted floodway or established base (100 year) flood elevations, it may be possible to construct a structure smaller than the existing structure as long as the upstream damage potential is low. Sound engineering judgment should be used when downsizing an existing structure.

- **U.S. Geological Survey (USGS) and U.S. Army Corps of Engineers stream gage information**

  Stream gage information is available from the USGS and U.S. Army Corps of Engineers for many sites in Iowa. If the drainage area at the project site is within 50% of the drainage area of the gage, the gage discharges should be used and transferred to the project site per the method specified in USGS WRIR 00-4233. If 25 years or more of stream gage data is available, the area-weighted estimate for ungaged sites on gaged streams is preferred over the regression-weighted estimate. Stream gage information may be obtained from the USGS in Iowa web site, the U.S. Army Corps of Engineers web site, or from the USGS WRIR 00-4233 publication.

http://ia.water.usgs.gov

http://www.mvr.usace.army.mil

- **USGS WRIR 87-4132 and USGS WRIR 00-4233 regression equations**

  If the project site is not located in a detailed FIS or within 50% of the drainage area of a gage, the USGS regression equations should be used to estimate peak discharges. The Iowa DOT currently recommends that the USGS 87-4132 report be utilized for projects that have drainage areas between 2 and 20 square miles. If USGS Report 87-4132 is used to determine Q50, see the commentary for a chart to estimate Q500. For drainage areas greater than 20 but less than 50 square miles, the Iowa DOT recommends that both the USGS 87-4132 and 00-4233 reports be used for estimating the design discharges and engineering judgment (possibly averaging both methods) be utilized for determining the peak discharges. If the drainage area is greater than 50 square miles, the Iowa DOT recommends using the USGS 00-4233 report.

  The USGS 00-4233 report utilizes one-variable equations for each of the three regions defined for the state. Two sets of equations are presented for Regions 2 and 3. The one-variable equations using only drainage area are considered easy for users to apply. However, the predictive accuracies of the multi-variable equations are better and therefore, the multi-variable equations should be used over the one-variable equations.

  The Main-Channel Slope (MCS) variable is used for the flood-frequency estimation equations for Region 2 and Region 3. The USGS WRIR 03-4120, "Main-Channel Slopes of Selected Streams in Iowa for Estimation of Flood-Frequency Discharges" was published to provide a graphical representation of the MCS curves for 138 selected streams in Iowa with drainage areas greater than 100 square miles. The MCS values determined from the curves can be used in regression equations for estimating flood-frequency discharges for ungaged stream sites in Iowa.

- **~~Corps of Engineers, Iowa DNR, and~~ USGS flood reports**

  ~~Miscellaneous~~ Open file flood reports by the ~~Corps of Engineers, the Iowa DNR, and the~~ USGS have been developed and can be valuable supplemental information when evaluating discharges and water surface elevations. The reports are listed and, in some cases, available for download as follows.

  ~~o Corps of Engineers and Iowa DNR studies~~
  ~~o USGS flood reports studies~~
  ~~o~~
  http://ia.water.usgs.gov/pubs/iowa.publications.html

  http://ia.water.usgs.gov/projects/profiles

3.2.2.2 Hydraulics

Once the peak discharges are determined for design, the structure must be analyzed to determine the hydraulic capacity or conveyance of the bridge waterway opening. Bridge hydraulics (freeboard and backwater) can be analyzed by utilizing various hydraulic programs such as HEC-2 or HEC-RAS, which are available from the Corps of Engineers or other sources; the Iowa DOT Bridge Backwater program based on the publication *Hydraulics of Bridge Waterways, HDS 1*; or WSPRO, which is available from FHWA. The designer should be aware of the assumptions and limitations for using the methodology in any hydraulic analysis program.

- **HEC-2 or HEC-RAS analysis**

  When a bridge is located within a detailed Flood Insurance Study (FIS) area, or the upstream flood plain has a high damage potential (such as a residence or business located in the upstream flood plain), the designer should perform a HEC-2 or HEC-RAS analysis to determine the impacts on flood elevations.

- **Iowa DOT Bridge Backwater program analysis**

  For bridges located in a rural area where the flood plain has a low damage potential, the designer may use the Iowa DOT Bridge Backwater program to analyze backwater and freeboard provided the conditions listed below are met.

  (1) The channel is relatively straight.
  (2) The floodplain cross section is fairly uniform.
  (3) The stream slope is approximately constant.
  (4) The flow is free to contract and expand.
  (5) There is no appreciable scour hole in the bed at the constriction.
  (6) The flow is in the sub critical range (Type I, non-pressure flow)

- **WSPRO analysis**

  For bridges located in a rural area where the flood plain has a low damage potential, the designer may use WSPRO program to analyze backwater and freeboard.

3.2.2.3 Backwater

Bridge backwater is caused by the encroachment of the road embankment onto the floodplain which constricts flood flows through the bridge opening. This constriction causes an increase in the normal stage (flood elevation without a bridge and roadgrade in place). The maximum backwater typically occurs one or two bridge lengths upstream.

Iowa DNR backwater criteria are listed in Table 3.2.10.1-2. In general, bridges should be designed to meet the backwater criteria even when a project does not require Iowa DNR approval. Variances to the backwater criteria can be obtained when it is not economical to meet the backwater criteria and when flowage easements are obtained for low damage potential areas.

Manning’s Equation is used to determine normal depth and a stage-discharge relationship (rating curve) for analyzing bridges. Typical roughness coefficients for the equation are given in Table 3.2.2.3.

Table 3.2.2.3. Manning's Roughness Coefficients for natural stream valleys (n-coefficients)

Description	Detailed Description	Manning's Coefficient
Channel, small to medium drainage areas	Irregular section, meandering channel, rocky or rough bottom, medium to heavy growth on bank and side slopes	0.04-0.05
	Uniform section, relatively straight, smooth earthen bottom, medium to light growth on bank and side slopes	0.03-0.04
Channel, large drainage area	---	0.025-0.35
Overbank flood plain, pasture land	No brush or trees	0.05-0.07
	Light brush and trees	0.06-0.08
Overbank flood plain, crop land	---	0.07-0.09
Overbank flood plain, brush and trees	Heavy weeds, scattered brush	0.08-0.10
	Medium to dense brush and trees	0.09-0.12
	Dense brush and trees	0.10-0.15
	Heavy stand of timber, a few downed trees, little undergrowth	0.07-0.10

Table note:

The table is from the Iowa DNR's Bridge Review Checklist at the following Internet address:

http://www.iowadnr.com/water/floodplain/files/bridgereviewformchecklist.pdf

3.2.2.4 Freeboard

Freeboard is the vertical clearance measured between the bottom of the superstructure and the 50-year flood elevation not including backwater. Typically this clearance is measured at the middle of the channel.

The purpose of freeboard is to provide adequate clearance for passage of debris and ice during high flows and to reduce the potential of superstructure submergence. Debris and ice jams can create horizontal and buoyant forces on the bridge superstructure and can reduce the bridge waterway opening resulting in increased velocity, scour, and upstream flood levels. When hydraulic modeling predicts that a span in a pretensioned prestressed concrete beam (PPCB) bridge will be inundated by the 100-year or lesser floods, the designer should recommend that beams in the span be vented to prevent buoyancy forces. (See BDM 5.4.2.4.2 for beam vent details.) The designer also should recommend venting a steel superstructure with integral abutments that will be inundated from abutment to abutment by the 100-year or lesser floods [BDM 5.5.2.4.2].

For streams draining more than 100 square miles (259 square kilometers) in rural (unincorporated) areas and for streams draining more than 2 square miles (5.18 square kilometers) in urban (incorporated) areas, the required Iowa DNR clearance between a 50-year flood and the low superstructure is 3.0 feet (910 mm) of freeboard. For streams draining less than 100 square miles (259 square kilometers) in rural areas and streams draining less than 2 square miles (5.18 square kilometers) in urban areas, no Iowa DNR permit is needed, so freeboard of 3.0 feet (910 mm) is not required but still is desirable.

Occasionally, a variance to the Iowa DNR freeboard criteria can be requested where one or more of the following conditions are present:

- The bridge is a floodplain overflow structure,
- Ice or debris is not expected to be a problem,
- Roadgrade overflow readily provides relief in the event the bridge opening is obstructed, or
- Raising an existing grade will result in excessive costs or damages, as in heavily developed urban areas.

3.2.2.5 Road grade overflow

New primary road profile grades generally should be designed to ensure that the 100-year flood elevation is not greater than the outside edge of shoulder. However, the designer should recognize that if the road grade is much higher, road grade overflow will not serve as a relief valve for the bridge during an extreme flood.

Changes to existing primary road profile grades on bridge replacement projects also need careful consideration. The designer should ensure that raising profile grades in areas with a history of roadway overtopping does not have a negative impact to adjacent property owners.

Coordination of the road grades with the Office of Design may be required.

3.2.2.6 Streambank protection

Streambank erosion is a natural process in which the stream adjusts to changing conditions within its channel and watershed. The main factors contributing to streambank erosion are the velocity of water, angle of attack, soil type, lack of vegetation, and changes in land use.

When stream velocities exceed 8 to 10 feet per second (2.4 to 3.0 meters per second), riprap may be considered. Past aerial photos should be examined to determine an approximate rate of erosion.

There are many streambank stabilization practices used by the engineering profession. A detailed description of the different methods is beyond the scope of these guidelines. However, because 75% of the streambank failures are caused by toe scour, a common design practice for bank protection with riprap is to provide adequate protection at the toe of the bank: a minimum 6-foot (1.830 m) from the toe or to the maximum scour elevation. The riprap should be a minimum 2-foot (600-mm) thick layer of Class E Revetment [IDOT SS 2507.03]. The bank slope generally should be 2~~.0~~ horizontal to 1 vertical.

As a general rule, any streambank protection design should not extend more than 25% of the width of the eroded channel, which includes the sandbar. The streambank protection design should be sufficiently keyed into the bank to prevent undercutting. For a bank toe protection example see the commentary for this article.

A good streambank stabilization resource is the Iowa DNR's manual *How to Control Streambank Erosion*. The manual may be downloaded from the following web site:

http://www.iowadnr.gov/water/stormwater/forms/streambank_man.pdf

3.2.2.7 Scour

Scour calculations should be made for all new and replacement bridges. The most common cause of bridge failure is from floods scouring bed material from bridge piers and abutments. Bridge scour is the engineering term for the movement of soil caused by the erosive action of water. Bridge scour is a complex process and difficult to analyze but very important in terms of bridge safety and maintenance cost. For guidance on calculating bridge scour the office generally relies on the Federal Highway Administration (FHWA) publication *HEC-18 Evaluating Scour at Bridges, 4th Edition* and the recommendations and guidelines published in "Iowa DOT Bridge Scour Guidelines." See the commentary for this article. ~~{Guidance will be added to the commentary for this article in the future.}~~

The effects of scour should involve a multidisciplinary review of hydraulic, geotechnical, and structural engineers to assess the stability of a structure.

"Iowa DOT Bridge Scour Guidelines" is derived from *HEC-18*. The main difference between the FHWA publication and the Iowa DOT methodology is the way pier scour is calculated. For most cases pier scour in Iowa has been calculated using the research performed by Laursen under "Iowa Highway Research Board Bulletin No. 4, Scour Around Bridge Piers and Abutments." *HEC-18* recommends the Colorado State University (CSU) equation for calculating pier scour. The Laursen equations and the CSU method give comparable results.

3.2.2.7.1 Types

There are two types of bridge scour: general or contraction scour and local scour.

- General or contraction scour is the decrease in streambed elevation due to encroachment of the road embankment onto the flood plain causing a contraction of flood flows, and
- Local scour is the loss of material around piers, abutments, wing dikes, and embankments.

There are two conditions for contraction and local scour: clear water and live-bed.

- Clear water scour occurs when there is little to no movement of the bed material of the stream upstream of the crossing. Typical situations include most overflow bridges without a defined channel, coarse bed material streams that could be found in northeast Iowa, ~~and~~ flat gradient streams during low flow, and bridges over main channels with a significant overbank length.
- Live-bed scour occurs when velocities are high enough to move the bed material upstream of the crossing. Most Iowa streams experience live-bed scour since they consist of sands and silts.

The designer should calculate the individual estimates of contraction, pier, and abutment scour. The designer should also consider long-term degradation when determining the total contraction scour depth. Local scour should be added below the contraction scour at each pier and abutment for evaluation. The designer should also apply engineering judgment when comparing results obtained from scour computations with available hydrologic and hydraulic data to achieve a reasonable and prudent design.

3.2.2.7.2 Design conditions

The design scour is determined for the 100-year or lesser flood, depending on which results in the most severe scour conditions. Usually the overtopping flood results in the worst scour, so evaluate this discharge if it is less than the 100-year flood. This scour depth is used by the final designer to check pile capacity and stability using load factors for the strength limit state.

The check scour is based on the occurrence of a 500-year or lesser flood, depending on which results in the most severe scour conditions. Bridge foundations will be evaluated by the final designer to ensure that they will not fail at the extreme event limit state due to the check (maximum) scour.

The preliminary situation plan hydraulic data block and longitudinal section shall show the design and check scour elevations.

3.2.2.7.3 Evaluating existing structures

When evaluating an existing bridge for scour, the designer should be aware of the procedures to evaluate the structure by engineering judgment to determine if it is scour-safe. A "Bridge Scour Stability Worksheet" and "Intermediate Scour Assessment Procedures" evaluation should be performed before proceeding with a calculated *HEC-18* scour analysis. This may significantly reduce the cost of analyzing structures for scour that could be considered scour-safe.

The "Bridge Scour Stability Worksheet" was developed in the early 1990s to assess structures based on the type of structure, observed conditions, and stream geomorphics. The structures were considered stable or scour-critical based on the point total determined from the worksheet.~~{A copy of the worksheet will be added to the commentary for this article in the future.}~~

The "Intermediate Scour Assessment Procedures" were developed in 1997 to provide additional assessment of existing structures that have not been evaluated for scour. A flowchart was developed to assess those bridges that could be considered scour-safe. ~~{A copy of the flowchart will be included in the commentary for this article in the future.}~~

If the structure is not determined to be scour-safe after assessment by the "Bridge Scour Stability Worksheet" or the "Intermediate Scour Assessment Procedure," a full computational analysis (*HEC-18*) must be performed.

3.2.2.7.4 Depth estimates

{Text for this article will be added in the future.}

3.2.2.7.5 Countermeasures

{Text for this article will be added in the future.}

3.2.2.7.5.1 Riprap at abutments

{Text for this article will be added in the future.}

3.2.2.7.5.2 Riprap at piers

{Text for this article will be added in the future.}

3.2.2.7.5.3 Wing dikes

~~{Text for this article will be added in the future.}~~The use of wing dikes (also called spur dikes or guide banks) shall be considered at any bridge site that has appreciable overbank discharge (25% or more of the total Q). Wing dikes help minimize backwater and scour effects. See the commentary for a table on selecting appropriate lengths of wing dikes and the Office of Design's manual [OD DM RL-3] for construction details. The riprap should typically be extended through the end of the wing dike.

3.2.2.7.6 Coding

{Text for this article will be added in the future.}

3.2.3 Highway crossings

3.2.3.1 Clearances

A grade separation design must satisfy both vertical clearance and horizontal clear zone requirements.

Vertical clearance distances at grade separation structures depend upon the mainline and side-road highway type and whether an interchange is present. Vertical clearance is measured from the low point of the overhead structure to the roadway, including the traffic lanes and shoulders. Minimum vertical clearance over primary highways is 16.5 feet (5.100 m) and over non-primary highways is 15.0 feet (4.600 m) [OD DM 1C-1]. For all primary over non-primary grade separations with an interchange, it is desirable to provide a clearance of 16.5 feet (5.100 m) [OD DM 6B-2, 1C-1].

Horizontal clear zone distances depend on design speed, average daily traffic (ADT), and slope type (cut or fill); see the table in the Office of Design's manual [OD DM 8A-2 ~~1C-2~~]. Use values in the fill slope portion of the table (fs ≥ 6:1). The horizontal clear zone is measured either from the edge of the traveled way in rural sections or from the back of curb in urban sections. Do not determine the clear zone based on the edge of the pavement, as this is typically 2 feet (600 mm) wider than the traveled way. If multiple highway types (mainline, ramps, loops auxiliary lanes, etc.) are present, use the clear zone that governs. Clear zones apply to both the bridge pier and berm slope together when a side pier is proposed. However, clear zone does not apply to the berm slope alone when there will be no side pier and a recoverable berm is proposed.

Horizontal clear zones should provide at least 14.5 feet (4.500 m) of vertical clearance [OD DM 8A-~~2~~ 2~~1C-2~~]. This vertical clear zone is to be maintained throughout the entire horizontal clear zone area.

3.2.3.2 Ditch drainage

If ditch drainage must be carried through the approach fills of a highway crossing structure, the designer should use a culvert rather than an open ditch, which increases the bridge length and cost. Ditch drainage may be conveyed behind the abutment due to excessive length and/or size of culvert.

3.2.4 Railroad crossings

The following articles are intended to provide guidance for obtaining agreements with the railroad for constructing within their right-of-way (ROW). Each project is unique and early coordination with the railroad regarding their design requirements and guidelines will help in the design process for grade separation structures. All Iowa DOT projects involving railroads should be coordinated at the concept stage through the Office of Rail Transportation.

The design requirements and guidelines for grade separation structures over the Burlington Northern ~~Sante~~Santa-Fe (BNSF) Railway and Union Pacific Railroad (UP) may be different than other railroad crossings. The requirements for railroads will vary depending upon ownership. For the purpose of preliminary bridge design of overhead structures, the guidelines are divided into two groups: BNSF and UP ownership, and Non-BNSF and UP ownership. The sections covering submittals and underpass structures will apply to BNSF, UP and other railroads.

For preliminary design of railroad crossings, federal funding limitations should be considered. Federal funding will not include costs associated with improvements that increase the cost of the bridge above the limits specified in the Code of Federal Regulations (CFR 646). Considerations include the level of commitment for future track expansion, vertical and horizontal clearances, and berm placement location. In general, it is Iowa DOT policy to accommodate the railroad's requirements unless a significant cost will be incurred. In some cases, two bridge TS&Ls may be required to determine the limit of federal participation for a project.

3.2.4.1 BNSF and UP overhead structures

The guidelines provided within this section are intended for overhead grade separation projects impacting the BNSF and UP Railroads. The requirements and guidelines generally follow BNSF and UP Railroad guidelines, but are applied from an Iowa DOT project development perspective. For additional information and detail, the designer may refer to sections 1, 2, 3, 4 and 5 of BNSF-UP's *Guidelines for Railroad Grade Separation Projects* [BDM 3.1.5.2], AREMA's *Manual for Railway Engineering* [BDM 3.1.5.2], and any applicable sections of the AASHTO LRFD Specifications.

3.2.4.1.1 Vertical clearance

The minimum vertical clearance from the top of rail elevation to low beam is 23'-4" (7.112 m). The BNSF and UP Railroads also request a 23'-4" (7.112 m) vertical clearance for a distance 25 feet (7.620 m) left and right of the centerline of track. Additional vertical clearance may also be requested by the railroad for correction of a sag in the track, construction requirements, and future track raises. To assist the railroad in evaluating the site specific needs, the profile of the existing top-of-rail, measured 1000 feet (304.800 m) each side of proposed overhead structure, shall be shown on the standard sheet [OBS SS 1067].

Federal funding limits may not allow for participation in the additional project costs associated with the desired 50 foot (15.240 m) wide vertical clearance envelope and additional clearance for future track raises. However, it is Iowa DOT policy to accommodate the requested clearances unless a significant expense will be incurred. Iowa DOT requests for variance to these desired additional clearances should be limited to these cases.

3.2.4.1.2 Horizontal clearance

The need to accommodate future track and/or access road must be coordinated with the Office of Rail Transportation in advance of establishing horizontal clearances for the bridge layout. These needs and requirements should be coordinated at the project concept stage, as they are a fundamental part of the bridge and roadway design development. Once the requirements for track and access road elements have been determined, the designer will be able to proceed to the next step of establishing pier and berm locations.

The BNSF and UP Railroads prefer all piers (including pier caps) and abutments to be located outside the railroad right-of-way. If this is not feasible, all piers and abutments should be located at least 25 feet (7.620 m) measured perpendicular from centerline of nearest existing or future track. In unique situations and subject to site conditions, the absolute minimum horizontal clearance requiring special review and approval by the railroad shall be 18 feet (5.486 m) measured perpendicular from the centerline of the track to the face of the pier protection wall.

Note that pier placement at the right-of-way line may also require an associated shifting of the bridge berm. Since the berm location determines the bridge length, shifting the berm out to the right-of-way may result in a bridge exceeding the length and cost allowed for federal participation. The cost difference may need to be provided to FHWA to determine the appropriate level of funding.

3.2.4.1.3 Piers

Piers within 50 feet (15.240 m), measured perpendicular from centerline of existing or anticipated future track shall be of heavy construction or shall be protected by a pier protection wall per Iowa DOT policy. Generally, for new bridges the office prefers the T-pier to satisfy heavy construction requirements in lieu of a pier protection wall. Top of pier footings located within 25 feet (7.620 m) from centerline of track shall be a minimum of 6 feet (1.829 m) below base of rail and a minimum 1 foot (305 mm) below the flow line of the ditch.

3.2.4.1.4 Bridge berms

It is the Iowa DOT policy to set the bridge berm location in accordance with the federal requirements. FHWA has indicated that full funding participation applies when the location of a bridge berm with a 2.5:1 slope is set at the top of rail elevation 26 feet (7.925 m) from centerline of the outermost track (27.5 feet (8.382 m) for 3:1 berm slope).

This method of setting the berm location provides for a small ditch sufficient for ballast to drain. Additional ditch drainage may require a culvert through the bridge berms to adequately convey the drainage. If a culvert is proposed, it must be analyzed to meet the BNSF and UP hydraulic design criteria summarized in the drainage section below.

Macadam stone slope protection should be proposed on the bridge berms. The railroad standard shows the slope protection terminating at the bottom of drainage ditch and must have a cut-off wall to protect the slope from scour/erosion. In all cases, the toe of slope shall be below the finished track or roadway sub-grade.

3.2.4.1.5 Drainage

Railroad corridors are constructed with a drainage system designed to keep runoff away from the tracks and ballast. The proposed construction shall safely pass high flows and not inhibit low flows. A complete hydrologic and hydraulic study is required whenever new or additional drainage is added to the railroad right of way, or when a drainage structure is scheduled to be added, removed, or replaced. The drainage report and support documentation must include hydraulic data (EGL, water surface elevations, and velocities) for both the existing and proposed conditions. If the proposed bridge structure will not change the quantity and characteristics of the flow in railroad ditches and drainage structures, the plan shall include a general note stating so.

The BNSF and UP Railroad standard provides for an open ditch under a bridge to convey drainage. An open ditch results in a longer bridge as compared to setting the berm per FHWA requirements. As a result of the funding limitations, it is the Iowa DOT policy to propose a culvert to convey the railroad ditch drainage through the bridge berm in lieu of an open ditch whenever possible. The BNSF and UP

Railroads have indicated that they will consider the acceptability of a culvert as a variance to their standard, but only if it can be demonstrated that the design Q_{100} headwater elevation will not rise above the sub-grade elevation (2’-3 (686 mm) below base of rail).

If use of a culvert is found to be unacceptable in terms of meeting the railroad hydraulic design criteria, the railroad standard flat-bottom or V-shaped drainage ditch should be incorporated. FHWA will make a case by case determination relative to their participation for funding of the additional bridge length required to accommodate the open ditch for this situation.

3.2.4.1.6 Barrier rails and fencing

Early coordination with the railroad regarding recommendations for barrier rail and fencing is desired.

On sidewalk or trail facilities the top of the fence should be curved to discourage climbing. A minimum 8-foot (2.438 m) vertical clearance should be provided for the full clear width of the trail or sidewalk. To prevent surface water from draining onto the railroad right of way, a one-foot (305-mm) parapet is required.

Fencing is also requested by the BNSF and UP on top of barrier rail on overhead structures without sidewalks or trails. Due to traffic safety concerns related to fencing on top of roadway barrier rail, the Iowa DOT generally proposes to the railroad that the fencing be omitted and that a 44-inch (1.118-m) barrier rail be provided to control the amount of snow and debris falling onto the track. This proposal is subject to site specific review and variance by the railroad.

The 44-inch (1.118-m) barrier rail and railroad fence requirements should be carried at a minimum to the limits of the railroad right-of-way or 25 feet (7.620 m) beyond the centerline of track, future track or access road, whichever is greater. Barrier and fence may be reduced back to a more standard configuration on the bridge once the railroad minimum requirements have been met. The bridge final designer will determine based on cost and constructability whether it is more economical to keep the fence and rail uniform for the full length of the bridge or to taper back as soon as allowable.

3.2.4.2 Non-BNSF and -UP overhead structures

The guidelines provided within this section are intended for overhead grade separation projects impacting non-BNSF and UP Railroads. The requirements and guidelines for each railroad may be different, but generally follow AREMA’s *Manual for Railway Engineering* [BDM 3.1.5.2] and any applicable sections of the AASHTO LRFD Specifications.

3.2.4.2.1 Vertical clearance

The preferred minimum vertical clearance from the top of rail elevation to low beam is 23'-4 (7.112 m) directly above the rail.

3.2.4.2.2 Horizontal clearance

The need to accommodate future track and/or access road and the determination of applicable rail company guidelines for horizontal clearance must be coordinated with the Office of Rail Transportation. These needs and requirements should be coordinated at the project concept stage, as they are a fundamental part of the bridge and roadway design development. Once the design criteria for track and access road elements have been determined, the designer will be able to proceed to the next step of establishing pier and berm locations.

It is desirable to provide pier (including pier caps) and abutment locations at least 25 feet (7.620 m) measured perpendicular from the centerline of nearest existing or future track. In unique situations and subject to site conditions, the preferred minimum horizontal clearance shall be 18 feet (5.486 m) measured perpendicular from the centerline of the track to the face of the pier protection wall. Horizontal clearance less than 18 feet (5.486 m) may be allowed on a case by case basis, if approved by the ~~R~~railroad.

~~It is desirable to provide pier and abutment locations at least 25 feet (7.620 m) measured perpendicular from the centerline of nearest existing or future track. In unique situations and subject to site conditions, the absolute minimum horizontal clearance shall be 18 feet (5.486 m) measured perpendicular from the centerline of the track to the face of the pier protection wall.~~

3.2.4.2.3 Piers

~~The need to accommodate future track and/or access road and the determination of applicable rail company guidelines for horizontal clearance must be coordinated with the Office of Rail Transportation. These needs and requirements should be coordinated at the project concept stage, as they are a fundamental part of the bridge and roadway design development. Once the design criteria for track and access road elements have been determined, the designer will be able to proceed to the next step of establishing pier and berm locations.~~

~~It is desirable to provide pier and abutment locations at least 25 feet (7.620 m) measured perpendicular from the centerline of nearest existing or future track. In unique situations and subject to site conditions, the absolute minimum horizontal clearance shall be 18 feet (5.486 m) measured perpendicular from the centerline of the track to the face of the pier protection wall~~.

Piers within 50 feet (15.240 m), measured perpendicular from centerline of existing or anticipated future track shall be of heavy construction or shall be protected by a pier protection wall per Iowa DOT policy. Generally, for new bridges the office prefers the T-pier to satisfy heavy construction requirements in lieu of a pier protection wall.

Top of pier footings shall be a minimum of one foot (300 mm) below finished ground line.

3.2.4.2.4 Bridge berms

It is the Iowa DOT policy to set the bridge berm location in accordance with the federal requirements. FHWA has indicated that full participation applies when the location of a bridge berm with a 2.5:1 slope is set at the top of rail elevation 26 feet (7.925 m) from centerline of the outermost track~~.~~(27.5 feet (8.382 m) for 3:1 berm slope).

This method of setting the berm location provides for a small ditch sufficient for ballast to drain. Additional ditch drainage may require a culvert through the bridge to adequately convey the drainage.

Macadam stone slope protection should be proposed on the bridge berms.

3.2.4.2.5 Drainage

Railroad corridors are constructed with a drainage system designed to keep runoff away from the tracks and ballast. If drainage must be carried through the approach fills, this should be accomplished by using a culvert, not by using an open ditch which increases the bridge length and cost. If the proposed bridge structure will not change the quantity and characteristics of the flow in railroad ditches and drainage structures, the plan shall include a general note stating so.

3.2.4.2.6 Barrier rails and fencing

Early coordination with the railroad regarding recommendations for barrier rail and fencing is desired.

Most of the railroad bridges carrying vehicular traffic will make use of the F-shape barrier rail. The designer shall determine the appropriate barrier rail height by consulting the Iowa DOT policy for bridge rail height. See BDM 5.8.1.1.1 and BDM 5.8.1.2.1.

Fencing shall be provided for the full length of bridge on all sidewalk or trail facilities. The standard 6-foot (1.829-m) high chain link fence is generally proposed.

On a case by case basis, there may be an alternative to rail or fence proposed. Reasons may include a request by the railroad or project aesthetics. A statement shall be included with the TS&L submittal to the Iowa DOT Office of Rail Transportation, relative to the proposal for barrier rail and fencing.

3.2.4.3 Underpass structures

Requirements for railroad underpass structures will follow the recommendations and guidelines applicable to the railroad company owner. Contact the Iowa DOT Office of Rail Transportation for coordination of applicable standards at the concept level of project development. Early coordination is necessary, as some railroad structures will require additional vertical clearance as compared to highway grade separation structures.

Once the proper design guidelines have been identified, the preliminary bridge design effort may be initiated. Special attention should be given to minimize project impacts on the railroad company service. If new alignment is not feasible or if staging is not agreeable to the railroad company, a shoofly bridge may be considered. All options shall be closely coordinated with the Iowa DOT Office of Rail Transportation.

3.2.4.4 Submittals

After TS&L completion, the Preliminary Bridge Section Leader will make the following documentation available to the Iowa DOT Office of Rail Transportation for submittal to the railroad:

(1) A response to railroad review comments on the concept submittal.
(2) A pdf file of the bridge TS&L.
(3) The site drainage report, if drainage is affected.
(4) A bridge plan view showing the location of the proposed shoofly (only for railroad underpass bridges).
(5) If the project will be constructed in stages, controlling dimensions should be included on the TS&L.
~~(5)~~(6) For BNSF and UP RR submittals, top of rail profile information [~~(Standard Sheet~~OBS SS 1067]~~)~~.

3.2.5 Pedestrian and shared use path crossings

Guidance for sidewalk and shared use paths on roadway bridges is covered under Superstructures, Width, Sidewalk, separated path, and bicycle lane [BDM 3.2.6.2.2], and Office of Design's Design Manual [OD DM ~~C~~11A-1 & 11A-2].

The following references provide additional information related to the design of shared use paths and bicycle facilities: AASHTO's 1999 *Guide for the Development of Bicycle Facilities* [BDM 3.1.5.2]; the design guidelines (Chapter 4) in *Iowa Trails 2000* [BDM 3.1.5.2], and *2009 SUDAS Standard Specifications* [BDM 3.1.5.2].

- **Pedestrian or shared use path bridge**

  For a separate pedestrian or shared use bridge, the office recommends a minimum clear width of 12 feet (3.600 m). This is different than our recommended 10-foot (3.000-m) clear width on vehicular bridges due to the minimal increase in cost to provide 12 feet (3.600 m) on a separate bridge.

  To assist in snow removal, the deck cross section should slope 2% in one direction across the full width. It is often desirable to include concrete parapets at the base of the fence or railing to protect the fence from snowplow blades. Such parapets require a minimum footprint of 16 inches (400 mm) (plus 2-inch (50-mm) setback from slab edge) in order to accommodate the fence/railing anchorages. If no parapet is used, 12 inches (300 mm) is a sufficient fence/railing footprint on each side

For structures over a roadway, the desirable minimum vertical clearance is 17.50 feet (5.334 m). Provisions for additional clearance may be considered for unique bridges. It is undesirable to use truss bridges over our highways due to damage from over-height loads and the lack of proper fencing to prevent debris from falling/thrown onto the roadway below. A girder bridge with a concrete deck and proper fencing is preferred for recreational or trail bridges over a roadway.

For structures over a waterway, the structure low beam should generally be designed at the Q_{10} water surface elevation. Typically, relief in the approach grading should be provided for discharges greater than the Q_{10}. Since waterway structures will be inundated by larger floods, the designer should consider the expected buoyant forces. In general, the bridge approach fill within the floodplain should be designed close to the floodplain grade. This is especially true if the construction will be within a detailed FIS area.

- **Pedestrian or shared use path under a roadway bridge**

  Adjacent to an urban roadway section, the desirable horizontal clearance from back of curb to sidewalk or shared use path is 6 feet (1.800 m) to allow for snow storage. If the offset from back of curb is less than 5 feet (1.500 m), a separation barrier is required. Adjacent to a rural roadway section or at a river or stream crossing, the location and offset of the pedestrian or shared used path should be coordinated with Office of Design. The desirable minimum vertical clearance is from bridge low superstructure to sidewalk or shared use path is 10 feet (3.000 m), with a minimum of 8 feet (2.400 m).

  For both crossing types above, a 2-foot (600-mm) shy distance is desired from sidewalk or shared use path to bridge berm, and a 3-foot (900 mm) horizontal clearance is desired from sidewalk or shared use path to pier column.

  Greater shy distance should be considered for slopes steeper than 3:1 sloping down or away. Railings or dense plantings may have to be considered alongside certain grade conditions or ground covering (such as rip rap).

- **Pedestrian or shared use path through roadway embankment**

  In most cases, a standard sized 12-foot x 10-foot (3.600-m x 3.000-m) reinforced concrete box (RCB) structure is desired. The RCB size may be larger based on site conditions.

  Depending on the length of the RCB required, the location, and concerns about pedestrian safety, tunnel-type lighting may be appropriate. If a local municipality is involved this subject should be discussed during project concept/field exam stages and the information briefly noted on the TS&L.

  It may also be appropriate to note on the TS&L that the standard frost trough on the floor of the RCB shall not be used, which means some custom detailing is required in final design.

3.2.6 Superstructures

For typical highway bridge superstructures, the office generally selects among multiple options. If site and project conditions are appropriate the office prefers the following bridge types for which standard plans are available. The standard plans are available on the Office of Bridges and Structures web site:

http://www.iowadot.gov/bridge/index.htm

- **Three-span standard continuous concrete slab (CCS), J24, J30, J40, and J44 series [BDM 3.2.6.1.1]:** These standard CCS bridges are used for short spans up to 59 feet (17.983 m) or where minimum superstructure depth is required. There are nine bridge lengths from 70 feet (21.336 m) to 150 feet (45.720 m). The series includes roadway widths of 24 (which is not for primary highway system bridges), 30, 40, and 44 feet (7.315, 9.144, 12.192, and 13.411 m) and 0-, 15-, 30- and 45-degree skews. The standard plans are in English units only. The bridges are designed for HL-93 loading under the AASHTO LRFD Specifications.

- **Single span standard pretensioned prestressed concrete beam (PPCB), H24SI and H30SI series [BDM 3.2.6.1.2]:** These standard bridges have been withdrawn and will be redesigned using the AASHTO LRFD Specifications.

- **Three-span standard pretensioned prestressed concrete beam (PPCB), H24, H30, H40, and H44 series [BDM 3.2.6.1.4]:** These bridges are intended for highway or stream crossings. The standard beam bridges have nine lengths from 138'-10 to 243'-0 (42.316 to 74.066 m); 24- (which is not for primary highway system bridges), 30-, 40-, and 44-foot (7.315-, 9.144-, 12.192, and 13.411-m) roadways; and skews in 15-degree increments from 0 to 45 degrees, except that the H44 series is limited to a skew of 30 degrees. The standard plans are in English units only. The bridges are designed for HL-93 loading under the AASHTO LRFD Specifications. ~~The standard bridge plans for the two narrower roadways are under final review and will be released in 2010.~~

- **Three-span standard rolled steel beam (RSB) [BDM 3.2.6.1.5]:** These standard rolled steel beam bridges, which are intended primarily for stream crossings, have ten lengths from 160 to 340 feet (48.768 to 103.630 m), a roadway width of 40 feet (12.192 m), skews from 0 to 45 degrees, and span ratios of 0.75-1.00-0.75. The standard plans are in English units only. The bridges are designed for HL-93 loading under the AASHTO LRFD Specifications. ~~The standard bridge plans are under review and will be released in 2010.~~

If site conditions, roadway width, live loading, curvature, design method, or other considerations prevent use of the standard bridge designs the office prefers that the bridge be individually designed with either of the following.

- **Pretensioned prestressed concrete beam (PPCB) [BDM 3.2.6.1.6]:** PPCB bridges are used for spans to 155 feet (47.244 m). The designer shall select a single standard series of beams or bulb tee beams for the entire bridge. Within the series the designer should select among available beam lengths. For integral abutments the designer should limit skew to 45 degrees, and for stub abutments the designer should limit skew to 45 degrees.

- **Continuous welded plate girder (CWPG) [BDM 3.2.6.1.7]:** CWPG bridges are used for spans longer than 155 feet (47.244 m) or where minimum superstructure depth is required or where the horizontal alignment is sharply curved. There are no standard girder cross sections or lengths; each CWPG bridge is designed for the specific site and project conditions. For integral and stub abutments the designer should limit skew to 45 degrees.

~~The office also prefers that the bridge be configured for use of AutoBridge software. Use of AutoBridge has the following limitations:~~

- ~~Input and output in English units.~~
- ~~One to four spans.~~
- ~~Prestressed beam superstructure with the same standard beam type [BDM 3.2.6.1.6] in all spans.~~
- ~~Equal beam spacing.~~
- ~~Constant roadway width.~~
- ~~Horizontally straight bridge within one vertical curve or within tangent lines from one vertical curve.~~
- ~~Two integral abutments with identical plan dimensions, with optional changes in bearing and haunch thickness.~~
- ~~No longitudinal construction joints.~~
- ~~No splicing of transverse deck reinforcement.~~
- ~~Four identical wings.~~

- ~~Standard 7'-0 wings and wing extensions that may vary from the standard 6'-6 and 8'-0 lengths.~~

Grade separation design shall include the use of two-span bridges whenever practical as they minimize the use of piers, thereby increasing public safety. The designer shall consider various span arrangements based on the standard beam types available to optimize safety and cost efficiency. The face of pier and toe of berm slope shall be at or beyond the required clear zone distance for span arrangements with side piers. For the arrangements with no side piers, reference the article on berms [BDM 3.2.7.3] for additional guidance.

The guidelines listed above will cover most preliminary bridge designs. For exceptions and decisions regarding unusual project conditions the designer shall request approval from the supervising Section Leader.

3.2.6.1 Type and span

3.2.6.1.1 CCS J-series

For relatively small stream and valley crossings the office selects standard three-span continuous concrete slab superstructures. To facilitate the design of CCS bridges the office has prepared the signed standard J-series of plans.

The plans have the following parameters.

- The plans are in English units.
- The structures are designed for HL-93 loading.
- Roadway width is 24, 30, 40, or 44 feet (7.315, 9.144, 12.192, or 13.411 m). The 24-foot (7.315-m) width is intended for county bridges only.
- Skews may be 0, 15, 30, or 45 degrees.
- Bridge lengths range from 70 to 150 feet (21.336 to 45.720 m) as listed in Table 3.2.6.1.1.
- The maximum interior span of 59 feet (17.983 m) is approximately the upper limit for slab bridge economy.
- The ratios between interior and end spans are approximately 1.3 for efficiency.
- Substructure plans cover integral abutments and the option of monolithic or non-monolithic pier caps.
- There is the option for either an F-shape barrier or an open railing, except that only the open rail is available for the 24-foot roadway width.

Table 3.2.6.1.1. Lengths, spans, and depths for J24, J30, J40, and J44 three-span continuous concrete slab bridges (This table is the same as Table 5.6.2.1.1.)

Length (1) feet (m)	End Span (2) feet (m)	Interior Span (3) feet (m)	Depth inches (mm)
70 (21.336)	21.00 (6.401)	28.00 (8.534)	14.50 (368)
80 (24.384)	24.50 (7.468)	31.00 (9.449)	15.25 (387)
90 (27.432)	27.50 (8.382)	35.00 (10.668)	16.25 (413)
100 (30.480)	30.50 (9.296)	39.00 (11.887)	17.50 (445)
110 (33.528)	33.50 (10.211)	43.00 (13.106)	18.50 (470)
120 (36.576)	36.50 (11.125)	47.00 (14.326)	20.00 (508)
130 (39.624)	39.50 (12.040)	51.00 (15.545)	21.25 (540)
140 (42.672)	42.50 (12.954)	55.00 (16.764)	22.50 (572)
150 (45.720)	45.50 (13.868)	59.00 (17.983)	24.00 (610)

Table notes:

(1) Length is measured from centerline of abutment to centerline of abutment.
(2) End span is measured from center of abutment to center of pier.
(3) Interior span is measured from center of pier to center of pier.

3.2.6.1.2 Single-span PPCB HSI-series

This series of standard plans temporarily has been withdrawn for revision to the AASHTO LRFD Specifications.

3.2.6.1.3 Two-span BT-series

This series of standard plans has been withdrawn and will not be reissued.

3.2.6.1.4 Three-span PPCB H-series

For typical highway and stream crossings the office has developed standard plans for three-span pretensioned prestressed concrete beam (PPCB) bridges.

The signed standard plans have the following parameters.

- The plans are in English units.
- The structures are designed for HL-93 loading.
- Roadway width is 24, 30, 40, or 44 feet (7.315, 9.144, 12.192, or 13.411 m). The 24-foot (7.315-m) width is intended for county bridges only.
- Skews may be 0, 15, 30, or 45 degrees, except that the 45-degree skew is not available for the H44 series.
- The four- to seven-beam cross section makes use of standard A, B, and C beams, depending on span.
- Substructure plans cover integral abutments and pile bent or T-piers.
- There is the option for either an F-shape barrier or an open railing for all but the H24 series. The H24 series has an open railing only.

The ranges of lengths, spans, and beam depths are given in Table 3.2.6.1.4.

Table 3.2.6.1.4. Lengths, beams, and beam depths for H24, H30, H40, and H44 three-span PPCB bridges

Length (1) feet-inches (m)	End Span (2) feet-inches (m)	Interior Span (3) feet-inches (m)	Beam Series	Beam Depth (4) feet-inches (mm)
138-10 (42.316)	43-3 (13.183)	52-4 (15.951)	A	2-8 (8130
151-4 (46.126)	47-5 (14.453)	56-6 (17.221)	A	2-8 (813)
163-10 (49.936)	51-7 (15.723)	60-8 (18.491)	B	3-3 (991)
176-4 (53.746)	55-9 (16.993)	64-10 (19.761)	B	3-3 (991)
188-10 (57.556)	59-11 (18.263)	69-0 (21.031)	B	3-3 (991)
201-4 (61.366)	64-1 (19.533)	73-2 (22.301)	C	3-9 (1143)
213-10 (65.176)	68-3 (20.803)	77-4 (23.571)	C	3-9 (1143)
226-4 (68.986)	72-5 (22.073)	81-6 (24.841)	C	3-9 (1143)
243-0 (74.066)	80-9 (24.613)	81-6 (24.841)	C	3-9 (1143)

Table notes:

(1) Length is measured from centerline of abutment to centerline of abutment.
(2) End span is measured from centerline of abutment to centerline of pier.
(3) Interior span is measured from centerline of pier to centerline of pier.
(4) Add beam depth, 8-inch (203-mm) deck, and 3-inch (76-mm) estimated haunch to determine superstructure depth.

3.2.6.1.5 Three-span RSB-series

For typical stream crossings the office has developed signed standard plans for weathering steel, three-span rolled beam bridges. The 2010 plans meet the AASHTO LRFD Specifications. Because cost experience with these bridges is limited, if a standard rolled beam bridge is feasible for a bridge site the designer also shall layout an equivalent PPCB bridge and consult with the supervising Section Leader regarding the choice of bridge type.

The rolled beam plans have the following parameters.

- The plans are in English units.
- The structures are designed for HL-93 loading.
- Roadway width is 40 feet (12.192 m).
- Skews may be 0, 10, 20, 30, or 45 degrees.
- The six-beam cross section makes use of W30 to W44 (W750 to W1100) shapes.
- Substructure plans cover integral abutments and T-piers.
- Only an F-shape barrier rail is provided.

The range of lengths and spans are given in Table 3.2.6.1.5.

Table 3.2.6.1.5. Lengths, spans, and beam depths for RSB three-span continuous bridges

Length (1) Feet (m)	End Span (2) feet (m)	Interior Span (3) Feet (m)	Beam Depth (4) feet-inches (mm)
160 (48.768)	48 (14.630)	64 (19.507)	2-6 (762)
180 (54.864)	54 (16.459)	72 (21.946)	2-6 (762)
200 (60.960)	60 (18.288)	80 (24.384)	2-9 (838)
220 (67.056)	66 (20.117)	88 (26.822)	2-9 (838)
240 (73.152)	72 (21.946)	96 (29.261)	3-0 (914)
260 (79.248)	78 (23.774)	104 (31.699)	3-4 (1016)
280 (85.344)	84 (25.603)	112 (34.138)	3-4 (1016)
300 (91.440)	90 (27.432)	120 (36.576)	3-4 (1016)
320 (97.536)	96 (29.261)	128 (39.014)	3-4 (1016)
340 (103.632)	102 (31.090)	136 (41.453)	3-8 (1118)

Table notes:

(1) Length is measured from centerline of abutment to centerline of abutment.
(2) End span is measured from centerline of abutment to centerline of pier.
(3) Interior span is measured from centerline of pier to centerline of pier.
(4) Add beam depth, 8-inch (203-mm) deck, and 3-inch (76-mm) estimated haunch to determine superstructure depth.

These three-span standard bridges are not readily adaptable to other span, length, or skew conditions.

3.2.6.1.6 PPCB

The majority of the bridges designed for Iowa highways make use of standard pretensioned prestressed concrete beams (PPCB). Presently there are eight series of beams listed in Table 3.2.6.1.6 that are available. The eight series allow for design of bridges with single spans or multiple spans with varying span lengths.

In general the A-D series beams are preferred for both detailing and cost reasons. However, in some cases the bulb tee beams, BTB through BTE, may be better choices.

Various factors should be considered with the BTB through BTE series beams:

- Longer spans: For span lengths greater than 110 feet (33.500 m), consider the BTC, BTD, and BTE beams with a steel girder option.
- Vertical clearances: For structures with tight vertical clearances where the A-D series beams cannot be used, consider the shallower BTB and BTC beams with a steel girder option.
- Profile grade adjustments: For replacement bridge projects where substantial cost increases are incurred with profile grade adjustments necessary to accommodate the A-D series beams, consider the shallower BTB and BTC beams with a steel girder option. For roadway alignments on relocation, costs associated with profile grade adjustments are generally considered part of the plan development process.
- High skews: The bulb tee beams are designed for skews of 30 degrees or less. Use of the bulb tees in skewed structures will require wider abutment and pier caps to accommodate the wide bottom flange of 30 inches (760 mm). For bridges with skews greater than 30 degrees, the designer should consult with the supervising Section Leader.
- Estimated haunch limitations: When considering the use of bulb tee beams, take into account the geometrics of the roadway. For long spans on roadways with sharp vertical and/or horizontal curves, the longer bulb tee beams may not be feasible because of the large haunches necessary for vertical curves and offsets necessary for horizontal curves [BDM 3.2.6.3]. The preliminary designer may estimate the haunch dimensions using the calculation method given in the commentary. In cases where the estimated haunch limitations are exceeded, the designer should consider other beam types and span arrangements.

- Longer spans for reducing numbers of piers: For longer bridges, the use of the longer span bulb tee beams can reduce the number of piers and may provide a more economical structure.

For exceptions to the guidelines above and decisions regarding unusual project conditions the designer shall request approval from the supervising Section Leader.

Table 3.2.6.1.6. Standard pretensioned prestressed concrete beams {This table is formatted in landscape position on the next page.}

Table 3.2.6.1.6. Standard pretensioned prestressed concrete beams

Beam Type							
A (1)	B (1)	C (1)	D (1)	BTB (2)	BTC (2)	BTD (2)	BTE (2)
Beam Depth, feet-inches (mm)							
2-8 (813) (3)	3-3 (991) (3)	3-9 (1143) (3)	4-6 (1372) (3)	3-0 (914) (3)	3-9 (1143) (3)	4-6 (1372) (3)	5-3 (1600) (3)
Span Length, Centerline to Centerline of Bearing, feet-inches (m)							
30-0 (9.144)		30-0 (9.144)		30-0 (9.144)	30-0 (9.144)		
34-2 (10.414)	34-2 (10.414)	34-2 (10.414)	35-0 (10.668)	35-0 (10.668)	35-0 (10.668)		
38-4 (11.684)	38-4 (11.684)	38-4 (11.684)	40-0 (12.192)	40-0 (12.192)	40-0 (12.192)		
42-6 (12.954)	42-6 (12.954)	42-6 (12.954)					
46-8 (14.224)	46-8 (14.224)	46-8 (14.224)	45-0 (13.716)	45-0 (13.716)	45-0 (13.716)		
50-10 (15.494)	50-10 (15.494)	50-10 (15.494)	50-0 (15.240)	50-0 (15.240)	50-0 (15.240)	50-0 (15.240)	
55-0 (16.764)	55-0 (16.764)	55-0 (16.764)	55-0 (16.764)	55-0 (16.764)	55-0 (16.764)	55-0 (16.764)	
	59-2 (18.034)	59-2 (18.034)	60-0 (18.288)	60-0 (18.288)	60-0 (18.288)	60-0 (18.288)	60-0 (18.288)
	63-4 (19.304)	63-4 (19.304)	65-0 (19.812)	65-0 (19.812)	65-0 (19.812)	65-0 (19.812)	65-0 (19.812)
	67-6 (20.574)	67-6 (20.574)					
		71-8 (21.844)	70-0 (21.336)	70-0 (21.336)	70-0 (21.336)	70-0 (21.336)	70-0 (21.336)
		75-10 (23.114)	75-0 (22.860)	75-0 (22.860)	75-0 (22.860)	75-0 (22.860)	75-0 (22.860)
		80-0 (24.384)	80-0 (24.384)	80-0 (24.384)	80-0 (24.384)	80-0 (24.384)	80-0 (24.384)
			85-0 (25.908)	85-0 (25.908)	85-0 (25.908)	85-0 (25.908)	85-0 (25.908)
			90-0 (27.432)	90-0 (27.432)	90-0 (27.432)	90-0 (27.432)	90-0 (27.432)
			95-0 (28.956)	95-0 (28.956)	95-0 (28.956)	95-0 (28.956)	95-0 (28.956)
			100-0 (30.480)	100-0 (30.480)	100-0 (30.480)	100-0 (30.480)	100-0 (30.480)
			105-0 (32.004)	105-0 (32.004)	105-0 (32.004)	105-0 (32.004)	105-0 (32.004)
			110-0 (33.528)		110-0 (33.528)	110-0 (33.528)	110-0 (33.528)
					115-0 (35.052)	115-0 (35.052)	115-0 (35.052)
					120-0 (36.576)	120-0 (36.576)	120-0 (36.576)
						125-0 (38.100)	125-0 (38.100)
						130-0 (39.624)	130-0 (39.624)
						135-0 (41.148)	135-0 (41.148)
							140-0 (42.672)
							145-0 (44.196)
							150-0 (45.720)
							155-0 (47.244)

Table notes:

(1) The normal distance from centerline of beam bearing to centerline of pier is 9 inches (229 mm). Exceptions require approval of the supervising Section Leader.

(2) The normal distance from centerline of bulb tee bearing to centerline of pier is 12 inches (305 mm). Exceptions require approval of the supervising Section Leader.

(3) Add beam, 8-inch (203 mm) deck, and 2-inch (51 mm) estimated haunch depth to determine superstructure depth.

Standard cross sections for PPCB bridges have roadway widths of 30, 40, and 44 feet (9.144, 12.192, and 13.411 m) [OBS SS 4380, 4383-4385, 4556-BTC-4 to 4561-BTE-6, 4380-BTB-4 to 4385-BTE-6].

3.2.6.1.7 CWPG [AASHTO-LRFD 2.5.2.6.3]

Continuous welded plate girder (CWPG) bridges are used for spans longer than 155 feet (47.244 m) or where minimum superstructure depth is required or where the horizontal alignment is sharply curved. The approximate maximum economical span is 300 feet (91 m) for constant depth girders and about 550 feet (168 m) for haunched girders. The office has standard CWPG bridge cross sections but custom designs the girder cross sections for each project.

Because of continuity, span lengths generally are balanced to avoid uplift and other undesirable conditions. To avoid uplift at the abutment and significant imbalance the office prefers that an end span be a minimum of 54% of the length of the adjacent interior span. For balanced moments the end span should be in the range of 75 to 80% of the length of the adjacent interior span. As a maximum, the office prefers that the end span not exceed 80% of the adjacent interior span.

Unless the bridge site presents vertical clearance or profile grade issues, the goal is to set composite girder depths (slab + girder) at about 1/25 of the span. If it is necessary to use shallower girders, the office prefers that the designer consider the AASHTO LRFD span-to-depth ratios to be minimum [see BDM 5.5.2.4.1.12, BDM C3.2.6.1.7, and AASHTO-LRFD 2.5.2.6.3]. CWPG superstructures typically have four or five girders spaced at 8.25 feet (2.400 m) to 10.25 feet (3.000 m). Spacings to 12 feet (3.660 m) are considered on a case-by-case basis. Usually interior and exterior girders are designed to be the same.

For exceptions to the guidelines above and decisions regarding unusual project conditions the designer shall request approval from the supervising Section Leader.

3.2.6.2 Width

3.2.6.2.1 Highway

Guidelines for bridge widths for new and reconstructed highways and for county roads are given in two chapters of the Office of Design's Design Manual [OD DM 1C-1, 6B]. See also bridge width needs for bridge inspection and maintenance accessibility [BDM 3.2.6.7].

For new bridges carrying freeways, expressways, super-two highways, rural two-lane highways, transitional facilities, and ramps and loops, the recommended bridge width is the lane widths plus shoulder widths. For new bridges carrying reduced-speed urban facilities and for existing bridges carrying all types of highways the recommended bridge width may be different than the approach roadway width [OD DM 1C-1].

For bridges carrying county roads in interchanges, the width should be set as for non-National Highway System (NHS), rural two-lane highways [OD DM 6B-2, 1C-1].

For bridges carrying county roads not in interchanges, the minimum width should be 30 feet (9.000 m) for an average daily traffic (ADT) of 1500 or less and 40 feet for an ADT greater than 1500 [OD DM 6B-3]. The 30-foot (9.000-m) minimum width provides for wide farm machinery. For county roads, in all cases the designer shall discuss the proposed width with the county engineer.

For interstate projects with paved medians, the bridge width may be greater than the lane widths plus shoulder width. AASHTO's *A Policy on Design Standards--Interstate System, 5th Edition* [BDM 3.1.5.2] states that the width of all bridges, including grade separation structures, measured between rails, parapets, or barriers shall equal the full paved width of the approach roadways. Special considerations are listed below.

- **A single median roadway barrier rail**

  It is usually desirable to provide a 2-inch (50-mm) gap between bridges and a ~~4-inch~~ 6-inch (~~100~~150-mm) gap between back of bridge barrier rail. ~~The 2-inch (50-mm) normal slab overhang behind barrier is reduced to 1 inch (25 mm).~~ If the median portion of the bridges will be used for temporary traffic staging and the barrier rail will be installed in a later stage, it will be desirable to construct a slotted drain between the bridges to provide drainage in the area of staged traffic.

- **A separated median roadway barrier rail**

  The barrier rail on the bridges will normally align with the approach roadway barrier rail, with the deck slab extending the typical 2 inches (50 mm). To retain the approach fill and median roadway pavement, the abutments should maintain the 2-inch (50-mm) gap. To accommodate staged traffic in the median portion, the bridge decks should follow the temporary traffic staging guideline in the paragraph above.

- **Bridges where a light pole blister or sign truss are proposed in the median between the bridges.**

  A sufficient clear distance between bridges to accommodate a light pole blister or sign truss is 2'-10 (864 mm). Contact the Office of Traffic and Safety to coordinate signing and lighting needs. In some cases, the proposed light poles or signs can be relocated beyond the bridges, or shifted to the outside.

3.2.6.2.2 Sidewalk, separated path, and bicycle lane

Because sidewalks on highway structures are costly, the office generally includes sidewalks only on urban structures or where a local agency agrees to pay the cost [OD DM 11A-2]. The minimum clear width is 5 feet (1.500 m). Wider sidewalks may be considered on the basis of approach sidewalks. When a sidewalk is proposed on a bridge, the designer should review the appropriate office guidance to determine whether to design raised sidewalks or sidewalks at grade. To assist in coordination with the Office of Design, the determination should be noted on the TS&L.

To accommodate shared use paths on highway structures, the office normally follows the width guidelines in the Office of Design's Design Manual [OD DM 11A-1]. A separated path on a bridge should normally be 10 feet (3.000 m) wide. This path width does not require a design exception even though it is narrower than the width recommended by AASHTO's *Guide for the Development of Bicycle Facilities* [BDM 3.1.5.2]. If especially heavy use is anticipated, a 12- or 14-foot (3.6- or 4.2-meter) wide bike path should be considered.

In determining width for sidewalk or separated shared use path, consideration should be given to bridge inspection and maintenance (See [BDM 3.2.6.7]). If there is good access underneath the bridge, a high lift can be used from below. However, special consideration should be given to bridges with limited access underneath or very high structures. For these cases, some additional guidance is listed below:

- To provide access for a typical bridge layout, a snooper on the bridge can reach over a 5-foot (1.500-m) wide sidewalk.
- To provide access for a steel welded girder bridge, a system of catwalks or cables on the girders may be considered. The girders need to be more than 6 feet (1.800 m) deep so the inspectors can stand up straight.
- To provide access for a very limited subset of bridges, such as tied arches or deck trusses, the designer should first coordinate with the office's maintenance and inspection unit staff before setting sidewalk or path dimensions. In some cases, sidewalk or path widths greater than 5 feet (1.500 m) should be increased to 12 feet (3.600 m) to allow for snooper access.

For both paths and sidewalks, the width should be labeled as clear width on the TS&L. This is to ensure that rail attached to the separation barrier does not encroach on the needed design width.

Although less common on roadway structures, designated bike lanes without barrier separation from traffic may also need accommodation. To provide for a bicycle lane adjacent to a driving lane on a bridge, the bicycle lane width should be 5 feet (1.500 m) wide, as measured from barrier rail to bicycle lane stripe at edge of driving lane.

3.2.6.3 Horizontal curve

If a bridge is to be placed along a horizontally curved alignment, the designer will need to decide how to configure the superstructure. For relatively insignificant curves, a superstructure may be constructed with straight beams or girders between locations of support, but for significant curves the beams or girders will need to be curved. With straight beams or girders the office prefers that all supports be skewed at the same angle so that all members within a span are the same length. The decision to require horizontally curved members generally limits the superstructure type and increases both final design and construction cost, so the designer needs to make the decision carefully.

The office has the following policy for horizontal curves. First, the designer shall determine the distance between the chord and arc, defined here as M, at the midpoint of the bridge. If M does not exceed 4 inches (100 mm), the bridge shall be designed on a chord at the designated full shoulder width. If M is larger than 4 inches (100 mm) but not larger than 12 inches (300 mm), before proceeding the designer shall consult with the supervising Section Leader. In most cases, for this intermediate curvature the bridge should be designed on a chord but slightly wider to provide full shoulder width or greater at all locations. If M is greater than 12 inches (300 mm), the bridge shall be designed on a horizontal curve.

If the bridge deck is to be constructed on a horizontal curve, the designer needs to consider the use of beams on chords or curved steel girders. When considering straight beams, the designer should check the offset for each span between the arc and chord. If any offset exceeds 9 inches (225 mm) a curved steel beam bridge should be considered.

In all cases, whether the bridge is designed on a chord or on a curve, the designer shall label bridge stationing from the centerline of the approach roadway. The stationing should be referenced from the design alignment as shown in Figure 3.2.6.3.

{Drawing will be added in the future.}

Figure 3.2.6.3. Horizontally curved bridge stationing layout

3.2.6.3.1 Spiral curve

The use of spiral curves in roadways in Iowa is an accepted practice to improve alignment and safety. In order to minimize the effects of complicated roadway geometry in bridges, spiral curves will either be moved off the bridge or eliminated from use [OD DM 2C-~~1~~]1] in order to simplify design and construction.

3.2.6.4 Alignment and profile grade

It is preferable that the horizontal alignment for a bridge be straight. Final design software usually can expedite the final design for a straight bridge. Where a curve in the alignment affects only part of a bridge, the designer should consult with the Office of Design to adjust the horizontal alignment to move the curve off the bridge, if possible.

It is preferable that the vertical alignment not create a flat, difficult-to-drain location on the bridge. If a low point is located on the bridge, the designer should consult with the Office of Design to adjust the vertical alignment to move the low point off the bridge [OD DM 2B-1].

For a two-span overpass in an urban location, a convex vertical alignment may cause excessive haunch above pretensioned prestressed concrete beams (PPCBs). The designer should be aware of the potential difficulty and consult with the Office of Design, if necessary.

When developing plans for bridges on four lane divided highways:

- Show the “Profile Grade Line” on the Situation Plan.
- Stations on the “Situation Plan” view should be shown at the “Centerline of Approach Roadway”. The elevations shown in the “Longitudinal Section Along Centerline of Approach Roadway” should coincide with the stations shown in the “Situation Plan” view.

For all bridges shown in longitudinal section, ~~S~~show top of bridge deck elevation taking parabolic crown into account (see commentary for this article).

3.2.6.5 Cross slope drainage

If a bridge contains an area that is flat or difficult to drain, a revision to the profile grade or cross slope may be desired. In cross slope transition areas, the preliminary designer shall check the slope gradients on the bridge. Each gradient is the vector sum of the cross slope and the grade. If the slope gradient is less than 2%, a revision to the profile grade or cross slope is desired. If a grade or cross slope cannot be revised to obtain a 2% gradient, the preliminary designer shall work with the roadway designer and the section leader to find an acceptable solution.

3.2.6.6 Deck drainage

Bridge deck drain locations are determined in final design [BDM 5.8.4 ~~5.2.4.1.2~~].

3.2.6.7 Bridge inspection/maintenance accessibility

For bridges with limited access underneath or with very high structures, inspections are normally performed from the roadway above requiring the use of a snooper. The maximum reach under a bridge with a snooper arm is 45 feet (13.716 m) based on a zero degree skew. Inspection access may also be obtained from a pedestrian/recreational pathway. See the article on Sidewalk, separated path, and bicycle lane [BDM 3.2.6.2.2]. The designer should coordinate with OBS Bridge Maintenance and Inspection to determine maintenance needs.

Dual bridges, 45 feet (13.716 m) or wider, may require access from both the outside and median side. The desired median clear width to provide snooper access is 7 feet (2.134 m). If the maintenance needs for separation will result in a shift of the roadway alignment or barrier rail, the designer should coordinate with the Office of Design.

When access from above is not practical for steel girder bridges, the following options will need to be considered.

- Inspection walkways
- Safety cables attached to girder webs

Other considerations for steel girder bridges:

- Weathering steel may require periodic washing.
- Painting of the exterior fascias in the median is recommended.

3.2.6.8 Barrier rails [AASHTO-LRFD 13.7.2]

The Highway Division Management Team recently approved a new policy for determining Test Levels (TL) and the associated heights for railings on new bridges on interstate and primary road bridges. The policy is intended to be a supplement to the current AASHTO LRFD Specifications [AASHTO-LRFD 13.7.2].

The new policy states the following:

- The need for a TL-6, minimum height 92 inches (2.340 m) railing is not anticipated for the vast majority of bridges in Iowa.

- All interstate mainline bridges shall require a TL-5 railing, minimum height 44 inches, 42 inches plus 2 inches (1120 mm, 1070 mm plus 50 mm) for future overlay.
- Bridge railing test level and the associated height for other primary highways shall be evaluated by the Pre-Design Section in the Office of Design for replacement structures and the Preliminary Bridge Section in the Office of Bridges and Structures for other bridges. Basically the evaluation will follow the flow chart in the commentary [BDM C3.2.6.8] and additional information in the policy statement.

The preliminary designer should note on the preliminary situation plan when TL-5 or other special rail is proposed.

Normally the preliminary designer is not involved in bridge rehabilitation projects. However, if the preliminary designer is involved with retrofit barrier rails on deck replacement, superstructure replacement, or widening projects on interstate or primary highway systems the designer shall consult with the Chief Structural Engineer. There may be special circumstances that require exceptions to the flow chart in the commentary [BDM C3.2.6.8].

3.2.7 Substructures

3.2.7.1 Skew

For horizontally straight bridges, skew is measured from centerline of roadway. For horizontally curved bridges, skew may be measured from centerline of roadway, a chord, or a tangent. Generally if the abutments and piers for a curved bridge will be radial it is convenient to measure the skew from the centerline of roadway, and if the abutments and piers will be parallel it is convenient to measure the skew from a chord or tangent. The method for determining skew on curved bridges should be noted on the situation plan.

Except in unusual cases the office limits skew to a maximum of 45 degrees. The office prefers to use integral abutments, and the 45-degree maximum skew will allow use of integral abutments for most bridges. A skew larger than 45 degrees requires approval of the supervising Section Leader. A highly skewed superstructure may require special final design, and the superstructure may require extra maintenance during its service life.

If the bridge will require stub abutments the office prefers that the skew not exceed 30 degrees. Except in unusual cases, the office limits the skew to a maximum of 45 degrees.

The skew for a straight bridge should be the same for all substructure components. If all substructure components have the same skew, beams or girders in the superstructure will be the same length, which will promote ease of fabrication and economy. The designer should seek approval of the supervising Section Leader if skews of substructure components will vary.

The office prefers that the designer set the skew to the nearest whole degree. The designer then should list this rounded skew in the title block for the situation plan but label the actual intersecting angle between the two roads on the plan view. However, if the new grade separation structure is adjacent to an existing structure that will remain in use, if horizontal clearance is limited, if a pier needs to fit a median barrier, or if the bridge is wide, the designer may set the superstructure to the appropriate exact skew angle rather than a rounded angle.

3.2.7.2 Abutments

Because of lower construction and maintenance costs the office prefers integral abutments as shown on standard sheets and standard plans for bridges. Integral abutments are limited by bridge length, end span length, and soil or rock conditions at abutment sites. For most sites, downdrag due to compressible fills will not affect the use of integral abutments because only the top portions of the piles flex, and the downdrag stresses occur below these regions of high bending stresses.

The conditions and table below are summarized from the detailed information in the abutment section of Bridge Design Manual, and that section should be consulted for additional information [BDM 6.5.1.1.1]. Table 3.2.7.2 assumes that a bridge has approximately parallel abutments and piers and that a bridge is straight or horizontally curved with straight beams or girders. The office generally does not use integral abutments for bridges with horizontally curved girders.

Table 3.2.7.2. Bridge length limits for use of integral abutments

Superstructure Type / Typical Pile	**Length and Skew Limits for Standard Integral Abutments**	**Maximum End Span / Prebore Length (2) / Minimum Pile Length**
PPCB / HP 10x57	575 (175.260 m) feet at 0-degree skew to 425 feet (129.540 m) at 45-degree skew (1)	Maximum A-D and BTB-BTE length / 10 or 15 feet (3.050 to 4.570 m) depending on load / 15 feet (4.570 m) to bedrock [BDM Table 6.5.1.1.1-1]
CWPG / HP 10x57	400 feet (121.920 m) at 0-degree skew to 300 feet (91.440 m) at 45-degree skew (1)	120 to 150 feet (36.580 to 45.720 m) / 10 or 15 feet (3.050 to 4.570 m) depending on load / 15 feet (4.570 m) to bedrock [BDM Table 6.5.1.1.1-2]
CCS / HP 10x42	400 feet (121.920 m) at 0-degree skew to 300 feet (91.440 m) at 45-degree skew (1)	45.5 feet (13.870 m) / 10 feet (3.050 m) / 15 feet (4.570 m) to bedrock

Table notes:

(1) Use linear interpolation of length for intermediate skew.

(2) Prebore depth is related to axial structural resistance of the pile. Final designer may adjust the depth.

If a working integral abutment is feasible at only one end of a bridge, the maximum length limit for the bridge shall be one-half the limit in the table, with no change in maximum end span length. In cases where a MSE retaining wall is used near an integral abutment, each pile shall be sleeved with a corrugated metal pipe (CMP) to control compaction near the pile as the embankment and MSE wall are built. Because the limits in Table 3.2.7.2 are more liberal than past limits, exceptions to these guidelines are not encouraged.

For relatively long, significantly curved, highly skewed, and other bridges that do not meet the integral abutment guidelines in Table 3.2.7.2, the designer should consider stub abutments. For many bridge and bridge site conditions stub abutments as detailed on standard sheets will be feasible. However, the designer will need to consider modifications to standard abutments and alternate abutment types for highly unusual bridges and bridge sites.

3.2.7.3 Berms

3.2.7.3.1 Slope

A bridge berm slope is generally normal to the bridge abutment, but also may be normal to a roadway or railroad under the bridge. Under normal situations the designer may make the following initial assumptions for berm slopes:

- For fill heights less than 30 feet (9.000 m) from grade to toe of berm, the steepest berm slope may be taken as 2.5:1, horizontal to vertical.
- For fill heights from 30-40 feet (9.000 m-12.200 m), the steepest berm slope may be taken as 3:1.
- For fill heights greater than 40 feet (12.200 m), contact the Soils Design Section for an initial berm slope estimate.

However, the designer shall also consider the following special situations:

- For bridges located over streams and rivers in the western Iowa Loess Hills counties (Woodbury, Monona, Harrison, Pottawattamie, Mills, and Fremont), and for bridges situated in meandered stream and river alluvial sites/environments statewide (See list in C3.2.10.1.), the designer should use a 3:1 berm slope with fill heights less than 30 feet (9.000 m) unless a steeper slope has previously been reviewed by the Soils Design Section. Note that bridges located over roads in upland Loess Hills areas are exempt from this shallower slope.
- For fill heights greater than 30 feet (9.000 m) on either Iowa Loess Hills stream and river sites or meandered stream and river alluvial sites statewide (See list in C3.2.10.1.), the designer shall contact the Soils Design Section for an initial slope estimate.
- For bridges statewide located in areas with special, unusual, extremely variable, and/or questionable soil conditions, the designer shall contact the Soils Design Section for an initial slope estimate.

If steeper slopes are required, they may be accommodated by reinforced steepened slope (RSS) techniques, by lightweight fill techniques, and/or by soil remediation techniques such as intermediate foundation improvements (IFIs) or core-outs, but steeper slopes require full coordination with and design by the Soils Design Section.

The initial assumptions for berm slopes discussed above are used to develop a preliminary Type, Size, and Location (TS&L) plan for a bridge. When final soils analysis shows that an alternate berm slope is required, either shallower or steeper, revisions to the TS&L may be required at that time.

The designer shall check the berm slope at all potential critical points along the berm. This will ensure that the required berm slope is provided anywhere on the berm.

Objects such as bridge piers and bridge berms can create a sight obstruction on the inside curve of a highway. Minimum sight distance is required based on curve radius, design speed, etc., measured along the centerline of the inside lane around the curve [OD DM 6D-4]. Bridge piers located at clear zones typically do not cause an obstruction. Bridge berms located at the edge of the shoulder and within or close to a horizontal curve need to be checked by the Office of Design to verify that the berm is not causing an obstruction. These bridges may need to be lengthened to accommodate sight distance.

3.2.7.3.2 Toe offset

To improve snow removal operations and storage and reduce maintenance costs for roadway grade-separation structures with no ~~out~~side piers, it is desirable to design the finished grade of the berm toe 5 feet (1.524 m) from the edge of shoulder. A minimum of 4 feet (1.219 m) offset is acceptable for PPCB bridges if sufficient beam length remains to obtain the 4-foot (1.219-m) minimum from the edge of shoulder to the toe. Use the next beam increment for that span if the minimum offset cannot be obtained. For CWPG bridges, set the toe of berm at the 5-foot (1.524-m) offset location. For standard design bridges, ensure that minimum toe offsets are obtained.

3.2.7.3.3 Berm slope location table

The berm slope location table (BSLT) provides key points on the bridge berm to define the "grading surface". This information is used by the Office of Design to calculate earthwork quantities and by the road contractor to assist in constructing the bridge berms. A BSLT shall be placed on the preliminary situation plan for all new bridges, or when a bridge is replaced or widened. Older versions of the BSLT on completed preliminary situation plan sheets will be grandfathered.

See the Office of Design's Standard Road Plans for earthwork [OD SRP EW 201-204] as these standards work with the BSLT. The "grading surface" represents the top of slope protection for grade separation structures. For river crossings, riprap may be placed on top of the grading surface or embedded below when needed to increase the bridge opening area. A typical section riprap detail identifying the "grading surface~~"~~ must be included on the TSL sheet to clearly show the intent. Refer to the commentary for additional guidance related to typical berm situations and example design details.

Points A, B and W are the key points used to describe the ~~"~~grading surface~~"~~. All points are defined by their elevation, station and offset (as referenced from the centerline of construction survey or survey baseline). The points are located a distance of 3 feet (900 mm) from the outside edge of the bridge. W is defined as the grading surface at the end of wing. To determine the elevation at W, drop 0.15 feet (45 mm) from the edge of shoulder elevation. B is at the top of berm and A at the toe of berm. Sometimes additional A or B points are needed to better define the berm, especially for bridges with skews greater than 15 degrees. The letters A, B, C and W are reserved for the bridge berm grading. If additional points are desired to better define the grading needed, use a different lettering scheme.

~~The berm slope location table (BSLT) provides the road contractor with additional information for constructing the bridge berms by defining key points along the toe and top of berm. A BSLT should be created for all new bridges, for replacement bridges with a significant amount of berm cut or fill, and for bridges for which the recoverable berm location table (RBLT) is required. In these cases, the BSLT should be placed on the preliminary situation plan. A BSLT is not required for bridge replacements or widenings, where only a small amount of berm shaping is needed.~~
~~The BSLT table identifies three points (A1, A2, and A3) at the toe of each bridge berm. Points A1 and A3 are located 3 feet (0.914 m) from the outside edge of the bridge deck. Point A2 is located on the centerline approach roadway. Sometimes additional A points are needed to better define the toe of the berm, especially for bridges with skews greater than 15 degrees.~~
~~The BSLT also identifies three points (B1, B2, and B3) at the top of each bridge berm. Points B1 and B3 points are located 3 feet (0.914 m) from the outside edge of the bridge deck. Point B2 is located along the centerline of approach roadway.~~
~~The stations and offsets for A and B points are referenced from the centerline of construction survey or survey baseline.~~
For roadway grade separation structures with no ~~outside~~ side piers, A points are defined where the finished grade of the berm meets the edge of the shoulder plus offset [~~Modified~~ OD SRP ~~RL-15~~ EW-203 and EW-204, BDM 3.2.7.3.2]. For roadway grade separation structures with side piers, A points are defined at the clear zone [OD SRP RL-13]. The designer can determine the elevations of A points from existing or proposed grade information for the roadway under the bridge and cross slopes of the pavement and shoulder. For a bridge over a stream, railroad, or urban roadway A points are defined where the toe of the berm meets the existing ground or proposed ground surface~~grade~~.
~~The designer should coordinate with the Office of Design to ensure that the BSLT information is incorporated in the grading plans. See also the standard bridge berm grading plan [Modified OD SRP RL-17], standard foreslope transition detail [OD RDD (Typical) 4303], and the example BSLT in the commentary for this article.~~

3.2.7.3.4 Recoverable berm location table

A recoverable berm location table (RBLT) provides bridge baseline station/offset and elevations for the various points to provide sufficient information for the contractor to construct the recoverable berm [~~Modified~~ OD SRP EW 203-204 ~~RL-15~~]. A recoverable berm is constructed for bridge berms with no outside piers and provides a flattened slope for errant vehicles. When the toe of the bridge berm is not located within the clear zone, an RBLT is not required.

The recoverable berm is represented by points B, C1, C2, and C3, as shown on the standard construction details sheet [~~Modified~~ OD SRP EW 203-204 ~~SRP RL-15~~]. Point B is located 3 feet (0.914 m) from the outside edge of the bridge deck at the top of the bridge berm. In order to create the flattened area for the recoverable berm, a line must be established that is 15 degrees or less from the edge of the lane (traveled way) to point B. This will establish the line segment BC from point B to point C2, which should be at a 6:1 horizontal to vertical or flatter slope. If the slope is greater than 6:1, the angle from the lane to point B must be lowered to graphically determine the limits of the recoverable berm.

The line segment BC intersects the edge of the shoulder at point C3. The elevation of point C3 is the edge of the shoulder elevation at that location. Point C2 is on line BC and is located a distance equal to twice the shoulder width from the edge of the traveled way. Continuation of the shoulder slope to point C2 determines the elevation.

The station distance between point C2 and C3 is defined as "X". A station distance "X" toward the bridge should be applied to determine the location of point C1. Point C1 should be 5 feet (1.524 m) from the edge of the shoulder unless otherwise noted on the preliminary bridge situation plan, minimum of 4 feet (1.219 m). See the standard road plan for bridge berms with no outside piers for more information [~~Modified~~ OD SRP EW 203-204 ~~RL-15~~, BDM 3.2.~~6~~7.3.2]. The elevation of point C1 is based on a continuation of the shoulder slope to that location. Point C1 is established to provide a transition from the recoverable berm back to the normal toe of the bridge berm. See the example RBLT in the commentary for this article.

3.2.7.3.5 Slope protection

This article covers slope protection guidelines for all except railroad bridges [BDM 3.2.4.1.4, 3.2.4.2.4].

- **Bridges over roadway**

  For bridges over a roadway, macadam slope protection is typically used. Concrete slope protection should be shown on berms adjacent to path or sidewalk facilities. Exceptions to this include proposing slope protection to conform to project aesthetic guidelines.

- **Bridges over waterway**

  For bridges over a waterway it is recommended that riprap be placed on the bridge berms due to limited maintenance resources and the potential for significant abutment scour. See also the article for riprap at abutments [BDM 3.2.2.6.5.1, to be added in the future]. In most cases, the riprap should be placed to the top of berm. For some sites, the top of berm may be at an elevation significantly higher than the 50 year flood elevation. In those cases, the riprap should only extend to the 50 year flood elevation.

  When the top of berm is significantly higher than the 50 year flood elevation, it is recommended that erosion stone be placed from the riprap to the top of berm to protect the berm slope from deck drains and local erosion/scour.

3.2.7.4 Piers and pier footings [AASHTO-LRFD 3.6.5]

For typical bridges the office selects among four pier types: frame pier, T-pier (hammerhead pier), pile bent, and diaphragm pier. Pier selection criteria include the following:

- **Waterway conditions:** For stream or river crossings, the most significant consideration in choice of pier type is the potential for ice or driftwood flow. If the drainage area is small, 50 square miles (130 square kilometers) or less, pile bents usually are acceptable for spans up to 100 feet (30.48 m). Consideration shall be given to the unbraced length of pile bent piers with respect to scour.

  Superstructure spans exceeding 100 feet (30.480 m) could require excessive number of piles and pile bent piers may not be economical. For longer spans the designer should consider T-piers [6.6.1.1.2], and in certain situations a frame pier may be considered. Regardless of drainage area, however, if significant ice or driftwood flow is expected, the pile bent shall be fully encased [BDM 6.6.1.1.3].

  If the drainage area is large, more than 50 square miles (130 square kilometers), or there is potential for significant ice or driftwood flow, the office strongly recommends T-piers.

For pier foundations in stream or river channels the office requires the designer to set the bottom of the footing about 6 feet (1.800 m) below the streambed elevation, regardless of the calculated scour elevations.

If piles are not feasible because sound rock is close to the waterway surface, the designer should consider diaphragm piers [BDM 6.6.1.1.4].

- **Roadway conditions:** For grade separations the most economical choice usually is frame piers. If a frame pier is within 30 feet (9.140 m) of edge of roadway [AASHTO-LRFD 3.6.5] and not sufficiently protected it will require a crash strut [BDM 6.6.4.1]. In that situation a T-pier is an alternative.

  Dual bridges placed edge to edge with a 2-inch (50-mm) gap generally should have separate piers for each bridge.

  Unless pier footings will bear on rock, the preliminary designer should set the preliminary bottom of pier footings 5 feet (1.520 m) below finished grade. The final bridge designer shall verify that the final bottom footing elevation allows for a minimum one foot (~~0.~~300 mm) cover thickness over the top of footing. ~~This depth will allow for a soil cover of one foot (0.300 m) and a footing thickness of 4 feet (1.220 m).~~

- **Railway conditions:** For railroad crossings, pier and footing guidelines are given in previous articles [BDM 3.2.4.1.3 and BDM 3.2.4.2.3]

- **Subsurface conditions:** The majority of Iowa pier foundations are supported on steel H-piles. If rock is close to the surface, spread foundations for piers may be notched into the rock layer.

  Drilled shafts socketed into rock may be an option on some sites [BDM 6.3.1.1].

- **Aesthetics:** If aesthetics are a consideration, the designer will need to follow the pier type and style established for the bridge.

3.2.7.5 Wing Walls

The preliminary designer shall verify that abutment wing walls provide an acceptable slope from the end wing to the berm. For typical PPCB or CWPG bridges, there should be no need to change standard wing wall lengths. However, if any of the following conditions apply, the designer shall check the need to increase wing wall lengths per criteria defined by BDM 6.5.4.3.1:

- Skew greater than 30 degrees
- Superelevation
- Beam depth greater than 63 inches (1.600 m), ~~(~~the BTE beam depth~~)~~.

Note that a 2.5:1 slope extended from the top of berm should be used for designing wings, even for situations with flatter berm slopes. The slope from the W point ~~(~~[BDM 3.2.7.3.3]~~)~~ to the top of berm elevation in the wing slope transition area should be 2:1 or flatter.

Any wing walls requiring more than 5 feet (1.5 m) beyond the standard length may be steepened to a 2:1 slope pending approval by the section leader. Non-standard wing lengths should be noted as such on the TSL. Final design will determine how the additional wing length will be addressed.

3.2.8 Cost estimates

For preliminary cost estimating, the designer should use the costs in Table 3.2.8, recognizing that the estimates will be reasonably valid for comparing bridge options but not accurate for current construction costs. For a typical new bridge cost estimate, multiply the unit cost in the table by the bridge deck area, measured from outside edge to outside edge of deck and from face to face of paving notch. Adjust the cost upward for complexity, staging, and other applicable costs using the amounts listed in the table. If the construction situation is highly unusual, consult the supervising Section Leader.

Table 3.2.8. Preliminary costs for typical Iowa bridges

Cost Item	Unit Cost (1), (2)
New continuous concrete slab (CCS) bridge	$ 75/ft^2 ($ 807/m^2)
New pretensioned prestressed concrete beam (PPCB) bridge	$ 80/ft^2 ($ 861/m^2)
New bulb tee (BT) bridge	$ 85/ft^2 ($ 915/m^2)
New rolled steel beam three-span standard bridge	$ 90/ft^2 ($ 969/m^2)
New continuous welded plate girder (CWPG) bridge	$ 100/ft^2 ($ 1076/m^2)
Complex bridges: variable width, urban area such as Des Moines, construction over traffic	Add for each item $5.00/ft^2 ($55/m^2)
Staged bridges	Add 10%
Cofferdam for pier construction	$25,000 per pier
Detour Bridge 40-foot (12.2 m)~~'long~~ span, 3 panel 32-foot (9.8 m) width~~(32' wide)~~	$30,000 per span
Bridge removal	$7.00/ft^2 ($75/m^2)
Bridge widening, including removal and staging	$ 200/ft^2 ($ 2153/m^2)
Mobilization	10%
Contingency	B0 =20% (3) D0, B1, D2 = 15% B2= 5%

Table notes:

(1) Unit costs for new construction do not include mobilization, removal of an existing structure, extensive river or stream channel work, large quantities of riprap, clearing and grubbing, approach slabs, and other construction work not part of the bridge.

(2) Unit costs were current as of April 2011 ~~July 2010~~.

~~(2)~~(3) See abbreviations [BDM 3.1.4] for definitions of these event codes.

~~(3) **3.2.8.1 Process for PSS cost estimates**~~

3.2.9 Preliminary situation plans

The office requires a preliminary situation plan for each new bridge and each bridge that is to be widened or lengthened. The plan and longitudinal section (or profile) views should be plotted at a 1 inch = 40 feet (1:500 for metric plans) scale on an 11-inch by 17-inch (280 mm by 432 mm) drawing. For long bridges the designer may use an alternate scale, provided that the alternate scale meets the approval of the supervising Section Leader.

Detailed structural design generally is not required for preparation of a preliminary situation plan. Thus pier and abutment details, pile types and lengths, and beam spacings need not be determined unless they affect vertical clearance, constructability, beam type, or structure length. Example preliminary situation plan drawings are shown in the commentary.

A preliminary situation plan for a bridge or culvert of bridge length over a waterway requires the following additional items:

- Hydraulic computations
- Backwater computations
- Scour computations

Preliminary situation plan submittal information to Iowa DOT should include the situation plan, hydraulic calculations, and surveyed valley cross section. The form "Risk Assessment for Bridges" (Form 621012) needs to be submitted for all consultant projects and for~~on~~ stream bridges that need FHWA approval. For a bridge-size RCB, length calculations shall be provided and either shown on a pink sheet or in some other format. An RCB is bridge-size when the clear span distance along centerline of roadway is more than 20 feet (6.1 m). The skewed distance along spans and interior walls shall be taken into account, but the exterior walls are not included.

A Preliminary Bridge Plan Checklist is provided on the Iowa DOT Bridge Office website. Consultants shall apply the checklist as needed and include it with the submittal.

~~{A checklist for preliminary situation plans and example plans will be added to the commentary for this article in the future.}~~

3.2.10 Permits and approvals

Iowa DOT projects are subject to federal and state laws and regulations and approval by agencies outside of the Iowa DOT. The majority of the permits and approvals apply to work in or over waterways, but there are also approvals applicable to railroad and highway grade separations.

3.2.10.1 Waterway

This article covers waterway requirements related to the following permits and coordination:

- Iowa Department of Natural Resources (Iowa DNR) Flood Plain Construction Permits (also called Flood Plain Development Permits),
- Records of Coordination of Flood Plain Development for cities and counties that participate in the National Flood Insurance Program (NFIP),
- Iowa DNR Sovereign Lands Construction Permits,
- Corps of Engineers 404 Permits,
- Corps of Engineers 408 Permits,
- Corps of Engineers 208.10 Approval, and
- Coast Guard Permits.

For a bridge or large culvert over a waterway the designer is obligated to meet the requirements of the Iowa DNR and other government agencies. Cases that require an Iowa DNR permit are summarized from the Iowa Administrative Code (IAC) in Table 3.2.10.1-1. Please review the DNR website for checklist and other required submittal information.

Table 3.2.10.1-1. Iowa DNR Flood Plain Construction Permit requirements (summary of IAC 567—Chapter 71)

Project Type	**Location**	**Construction Permit Required? Yes, if drainage area meets threshold.**
Bridges, culverts, or road embankments that cross the stream	Rural area[1] – floodway	100 square miles or more
	Urban area[2]	2 square miles or more
Road embankments that do not cross the stream	Rural area[1] – floodway and flood plain	10 square miles or more if obstructing 3% or more of the channel, or 15% or more of the flood plain
Channel changes[3]	Rural area[1] not associated with a road project	10 square miles or more
	Rural area[1] associated with a road project	10 square miles or more if (1) more than 500 feet of channel is being altered or (2) length of existing channel is reduced by more than 25%
	Urban area[2]	2 square miles or more
	Protected streams[4]	Any area
Bank stabilization	Rural area[1]	100 square miles or more
		10 to 100 square miles if channel cross section is being reduced by 3% or more
	Urban area[2]	100 square miles or more
		2 to 100 square miles if channel cross section area is being reduced by 3% or more
Levees, dams (ponds), flood plain excavation, or stockpiling	Varies[5]	Varies[5]

Table notes:

(1) Rural area is defined as any area not defined or designated as an urban area.
(2) Urban area is defined as an incorporated municipality.
(3) Channel change means either (a) the alteration of the location of a channel of a stream or (b) a substantial modification of the size, slope, or flow characteristics of a channel of a stream for a purpose related to the use of the stream's flood plain surface…. Increasing the cross-sectional area of a channel by less than 10 percent is not considered a substantial modification of the size, slope, or flow characteristics of a channel of a stream. See IAC 567—70.2.
(4) See IAC 567—Chapter 72 for a list of protected streams. Because petitioners may request that streams be added to the list at any time, the designer should contact the Iowa DNR regarding updates to the list if a project involves channel changes.
(5) See IAC 567—Chapter 71.

Through the permit process the Iowa DNR ensures that a bridge project meets the requirements of Flood Insurance Studies (FIS) of cities and counties participating in the National Flood Insurance Program (NFIP).

Any project on a stream that does not meet the drainage area thresholds in Table 3.2.10.1-1 does not require this type of permit or approval from the Iowa DNR. However, if the project is in a city or county that is participating in the NFIP, the designer shall perform a hydraulic review and coordinate with the community to ensure compliance with the NFIP. The designer shall complete a Record of Coordination of Floodplain Development form [BDM 3.2.11 and IDOT PPM 500.10] and forward copies of the form to the Iowa DNR and the appropriate District Engineer. The coordination effort is not considered a permit from the community. A complete list of cities and counties in the NFIP and status of their flood insurance studies is available at the following FEMA~~fema~~ web site: ~~from the Iowa DNR.~~

http://www.fema.gov/fema/csb.shtm

For a bridge that requires a Flood Plain Construction Permit the Iowa DNR establishes maximum backwater and minimum freeboard limits, and the limits are summarized in Table 3.2.10.1-2. If the structure exceeds the maximum backwater limits, the Iowa DNR may require that the Iowa DOT obtain flowage easements for the excess backwater.

Table 3.2.10.1-2. Iowa DNR backwater and freeboard requirements for bridges and culverts (summary of Iowa Administrative Code 567—Chapter 72)

Bridges and Associated Channel Changes[1]			
Damage Potential	**Maximum Backwater**		**Minimum Freeboard**
	Q_{50} and less	**Q_{100}**	
Low[2]	0.75 feet	1.5 feet	3.0 feet above Q_{50}
Moderate[3]	0.75 feet	1.0 feet	3.0 feet above Q_{50}
High[4] or Maximum[5]	0.75 feet[6]	1.0 feet[6]	3.0 feet above Q_{50}
Culverts and Associated Channel Changes[1]			
Culvert Type	**Maximum Backwater**		**Minimum Freeboard**
New culverts or culverts replacing bridges	Same as for bridges		No minimum[7]
Culverts replacing culverts	Backwater of existing culvert, or maximum backwater allowed for bridges, whichever is greater		

Table notes:

(1) These rules are applicable to channel changes on the floodway of any stream draining between 10 and 100 square miles when either (a) more than 500 feet of the existing channel is being altered or (b) the length of the existing channel is being reduced by more than 25 percent.

(2) Low damage potential means all buildings, building complexes, or flood plain use not defined as maximum, high, or moderate damage potential. See IAC 567—70.2.

(3) Moderate damage potential means flood damage potential associated with industrial and commercial buildings or building complexes containing readily movable goods, equipment, or vehicles and seasonal residential buildings or building complexes of which flooding would not result in high public damages…. See IAC 567—70.2.

(4) High damage potential means the flood damage potential associated with habitable residential buildings or industrial, commercial, or public buildings or building complexes of which flooding would result in high public damages…. See IAC 567—70.2.

(5) Maximum damage potential means the flood damage potential associated with hospitals and like institutions; buildings or building complexes containing documents, data, or instruments of great public value; buildings or building complexes containing materials dangerous to the public or fuel storage facilities; power installations needed in emergency or buildings or building complexes similar in nature or use to those listed above. See IAC 567—70.2.

(6) Backwater cannot exceed these values and must be minimized when it affects buildings, flood control works, etc., unless increase is mitigated or other measures are taken. See IAC 567—72.1(3).

(7) The Iowa DNR may evaluate freeboard on a case-by-case basis if debris and ice are a problem.

Any construction activity on, above, or under state-owned water and land requires an Iowa DNR Sovereign Lands Construction Permit. This permit is different from the Flood Plain Development Permit. There are portions of 14 rivers in Iowa that are legally classified as “meandered”, which means the State of Iowa owns the streambed and banks up to the ordinary high water mark. The meandered rivers are listed in the commentary for this article [BDM C3.2.10.1]. Submit a copy of the flood plain permit cover letter, joint application and the proposed plans to the Sovereign Lands Construction Permit Program for all projects that require DNR flood plain permit approval, even if it does not require a Sovereign Lands Construction Permit.

A Corps of Engineers 404 Permit is needed for all bridges over water, major highway projects, and stream bank repair projects. The designer should notify the Office of Location and Environment when the preliminary situation plan for a bridge is complete. The Office of Location and Environment will complete and submit a “Joint Application Form (Form 36)” [BDM 3.2.11] that will request the Corps of Engineers 404 Permit.

The Corps of Engineers also has requirements under 33 USC Section 408 to ensure that project modifications within a critical area of a Flood Risk Reduction Project (FRRP) constructed by the U.S. Army Corps of Engineers do not adversely impact the operation or integrity of the FRRP. The critical area is generally defined as 300’ riverward to 500’ landward of a FRRP centerline, but may be a greater distance if identified in a specific Operations and Maintenance Manual. If the proposed project does not change the level of protection or the authorized structural geometry or hydraulic capacity, the project may be approved under 33 CFR Section 208.10. Bridge replacement projects typically do not change the alignment or elevation of a flood protection levee. Therefore, most bridge projects will be considered a minor impact to the FRRP, but will still require Section 208 approval. Most bridge projects can be reviewed by the Corps with submittal of a TS&L and concurrence from the local agency in support of the project. The District will obtain concurrence from the local agency for the project, and preliminary bridge design will submit the Section 208 application. If the physical characteristics of the flood protection levee are modified or the operation or hydraulic capacity of the FRRP is changed, a more detailed submittal and review of the project will be required under Section 408.

~~The Section 408 submittal requires a coordinated effort between the Bridge Office, Office of Design and Office of Location and Environment. Bridge replacement projects typically do not change the alignment or elevation of a flood protection levee. Therefore, most bridge projects will require a Section 408 approval. Most bridge projects can be reviewed by the Corps with submittal of a T,S&L and concurrence from the local agency in support of the project. The District will obtain concurrence from the local agency for the projectHowever, any project over, under or through a FRRP will need approval under 33 CFR Section 208.10. If the physical characteristics of the flood protection levee are modified, Section 408 approval may be required.~~

The U.S. Coast Guard requires a permit for all projects over the Mississippi and Missouri Rivers. Appropriate horizontal and vertical clearances for the navigation channel shall be coordinated with the USCG during preliminary design. A letter from the USCG documenting the design criteria is desired for the file. Bridge Final Design submits the USCG permit application. The link to the permit application guide is: http://www.uscg.mil/d8/westernriversbridges/permitapplicationguide.asp.

3.2.10.2 Railroad

All bridges over railroads shall be reviewed and approved by the railroad company. The Office of Bridges and Structures (OBS) preliminary designer is referred to article 3.2.4.4 for railroad bridge submittal requirements.

3.2.10.3 Highway

In some cases Federal Highway Administration (FHWA) approval is required for federal funding programs. FHWA approval is required for major interstate projects or projects with modified interchanges. On a case by case basis, FHWA would also like to review bridges that are unique or controversial due to environmental or ROW issues. (Estimated contract value is no longer a consideration.)

The Office of Bridges and Structures will coordinate the FHWA approvals. The OBS preliminary designer shall submit a copy of the transmittal form and preliminary situation plan to the FHWA.

3.2.11 Forms

Preliminary design involves the use of several forms, not all of which are used on every project. A summary of the forms is given in Table 3.2.11. Blank Iowa DOT forms that have a form number can be downloaded from the form library at:

http://www.iadotforms.dot.state.ia.us/iowadotforms/Library.aspx

Table 3.2.11. Preliminary forms

Form Title	Form Number
Concept Form [(1)]	---
Iowa DNR Hydrology Pre-Approval Request Form	---
Joint Application Form for requesting Iowa DNR Flood Plain Construction Permits, Iowa DNR Sovereign Lands Construction Permits, and Corps of Engineers 404 Permits	36
Record of Coordination, Floodplain Development	~~532001~~
~~Scour Stability Worksheet~~	
~~Intermediate Scour Assessment Procedures~~	
Field Notes for Bridges (Bridge White Sheet) [(1)]	621004-E
Field Notes for Culverts (Pink or Pink Sheet)	621001-E ~~M~~
Transmittal sheet to FHWA for preliminary plans and supporting data	---
Risk Assessments for Bridges (Culverts) over Waterways [(1)]	517002 or 621012

Table note:

(1) See the commentary for examples of completed forms.

~~* See the commentary for examples of completed forms~~